



quarterly **a**nalysis review

18.2

2Q 2018

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25 june 2018

topics

1

energy markets

automotive markets

technologies studies

environmental studies

behavior & opinion surveys

policy & business studies

qar

outline

1 energy markets

gasoline prices

- > EIA: Gasoline prices are at their highest point in 4 years
- > FOTW: DOE's eGallon is 10-70% lower than cost of gasoline

oil production

- > EIA: Crude oil and gasoline exports are at record levels

energy consumption

- > FOTW: Plug-in vehicles consumed 2 TWh of energy in 2017 and offset 200 million gallons of gasoline

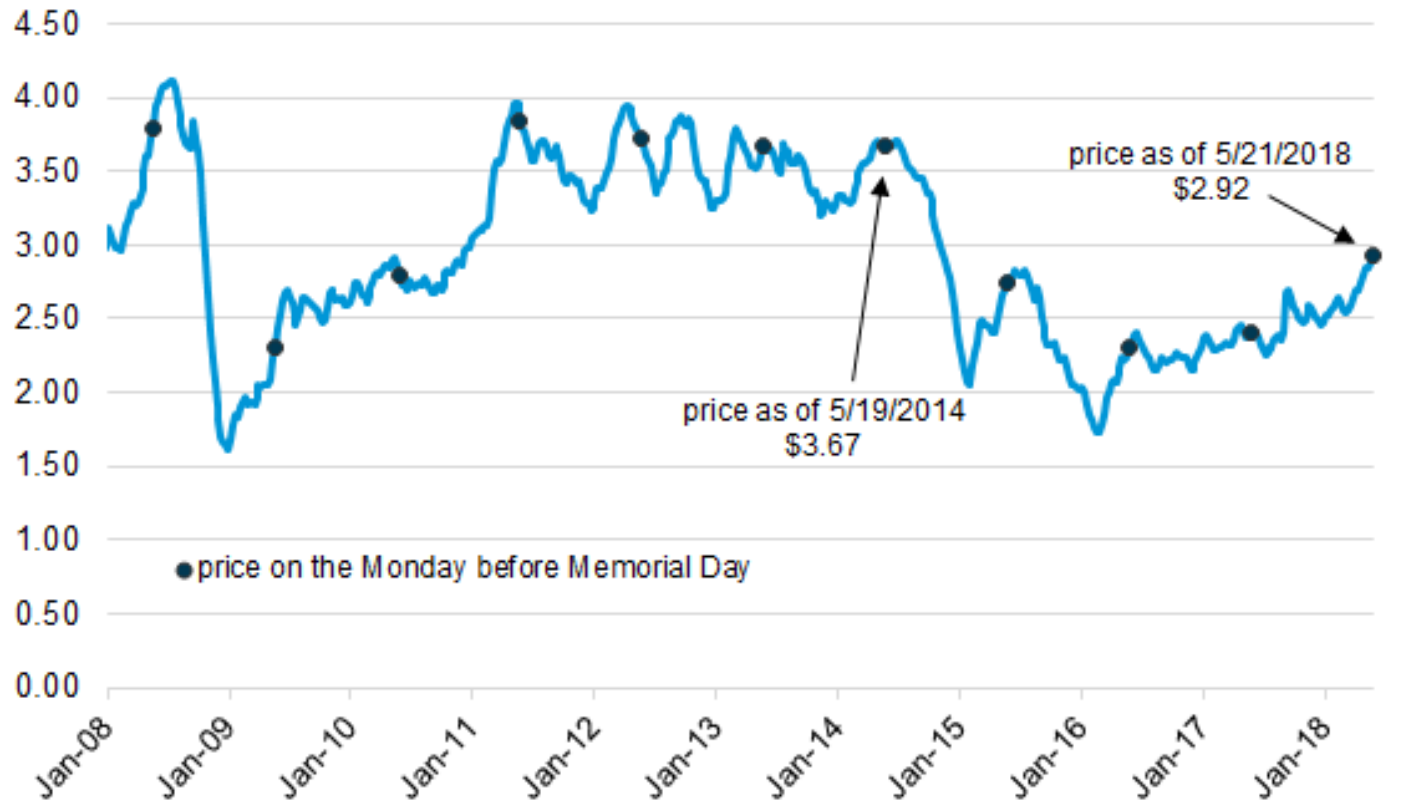
high-octane fuels

- > FOTW: The price difference between regular and premium gasoline continues to increase

gasoline prices

EIA: Memorial Day gasoline prices in 2018 were at their highest level since 2014

Figure 1. U.S. average regular gasoline price
dollars per gallon

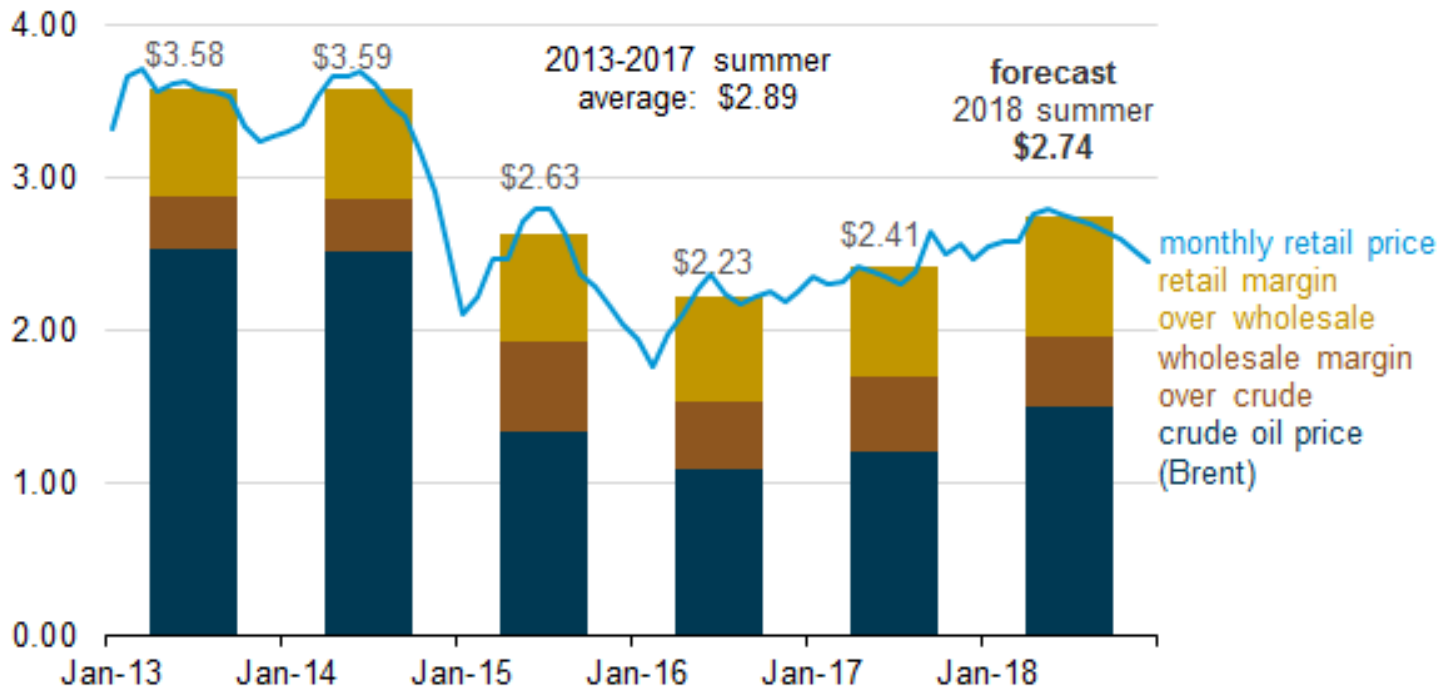


Source: U.S. Energy Information Administration, Gasoline and Diesel Fuel Update

gasoline prices

EIA: Gasoline prices this summer are expected to be 11% higher than in summer 2017

Figure 1. U.S. regular-grade gasoline retail price and summer (April through September) average
dollars per gallon

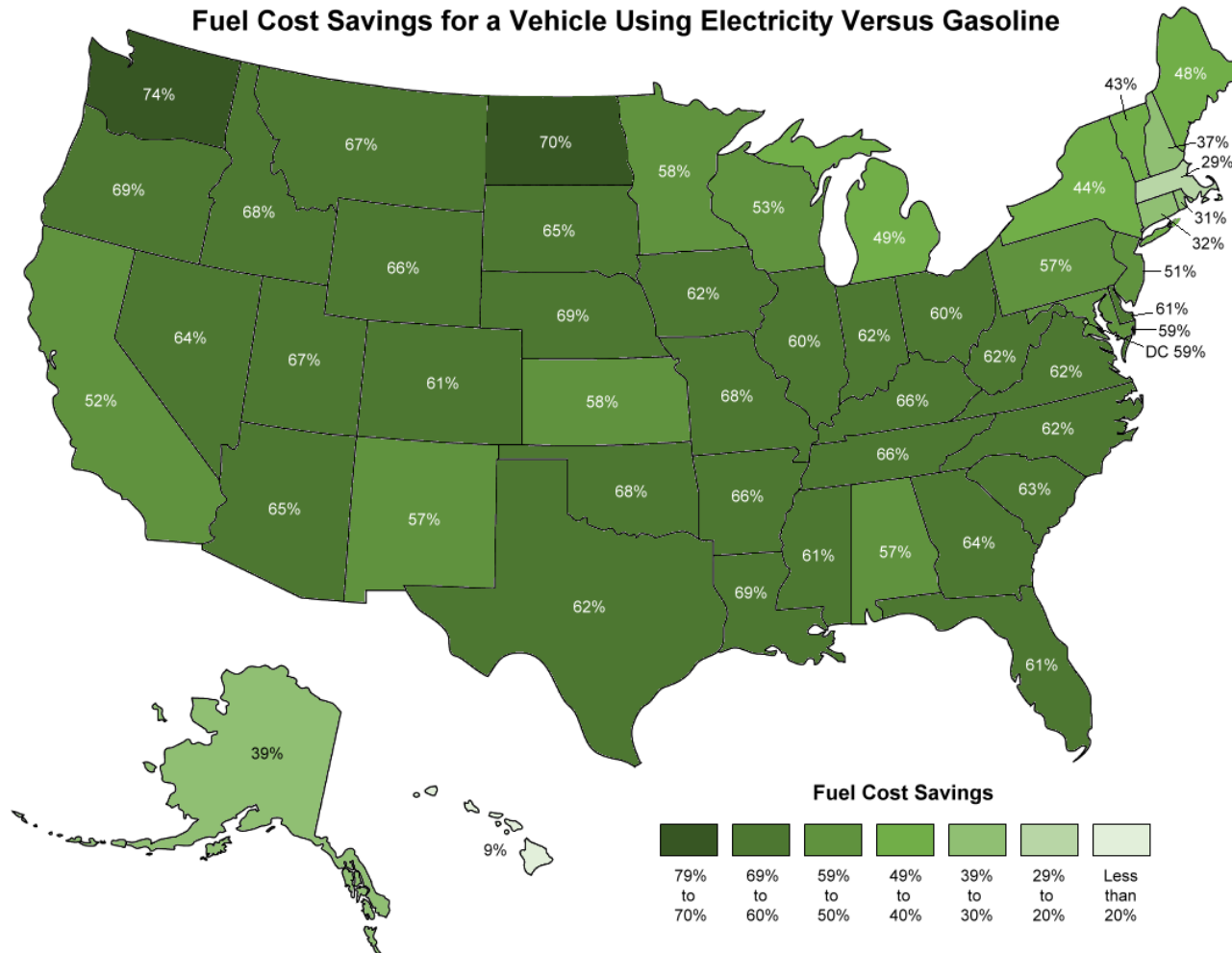


Note: Retail margin includes state and local taxes.

Source: U.S. Energy Information Administration, *Short-Term Energy Outlook*, April 2018

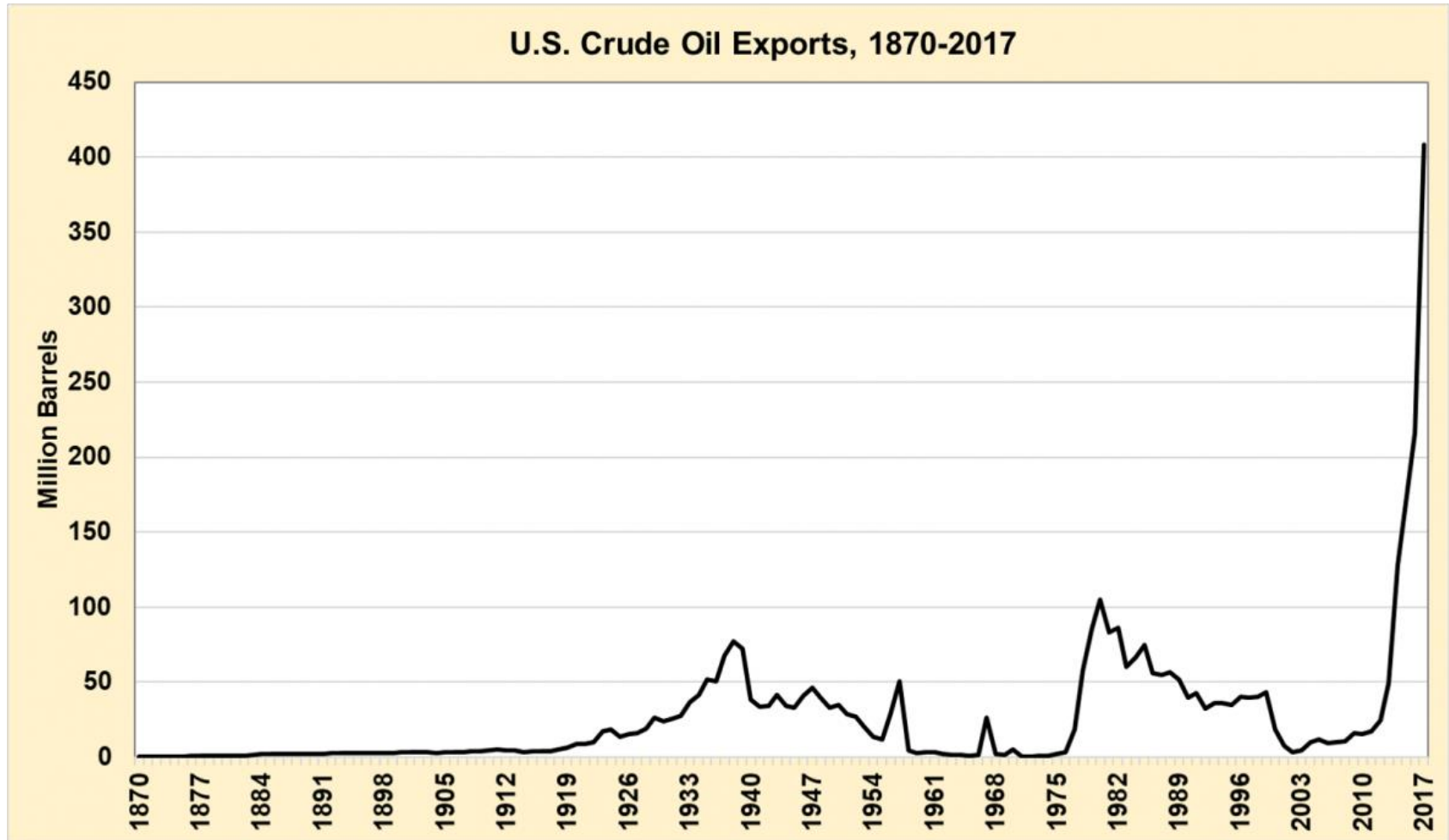
fuel prices

DOE: The cost of driving an electric vehicle (eGallon) is cheaper than an average ICE vehicle in every state



oil markets

FOTW: U.S. crude oil exports skyrocketed in 2016 and 2017

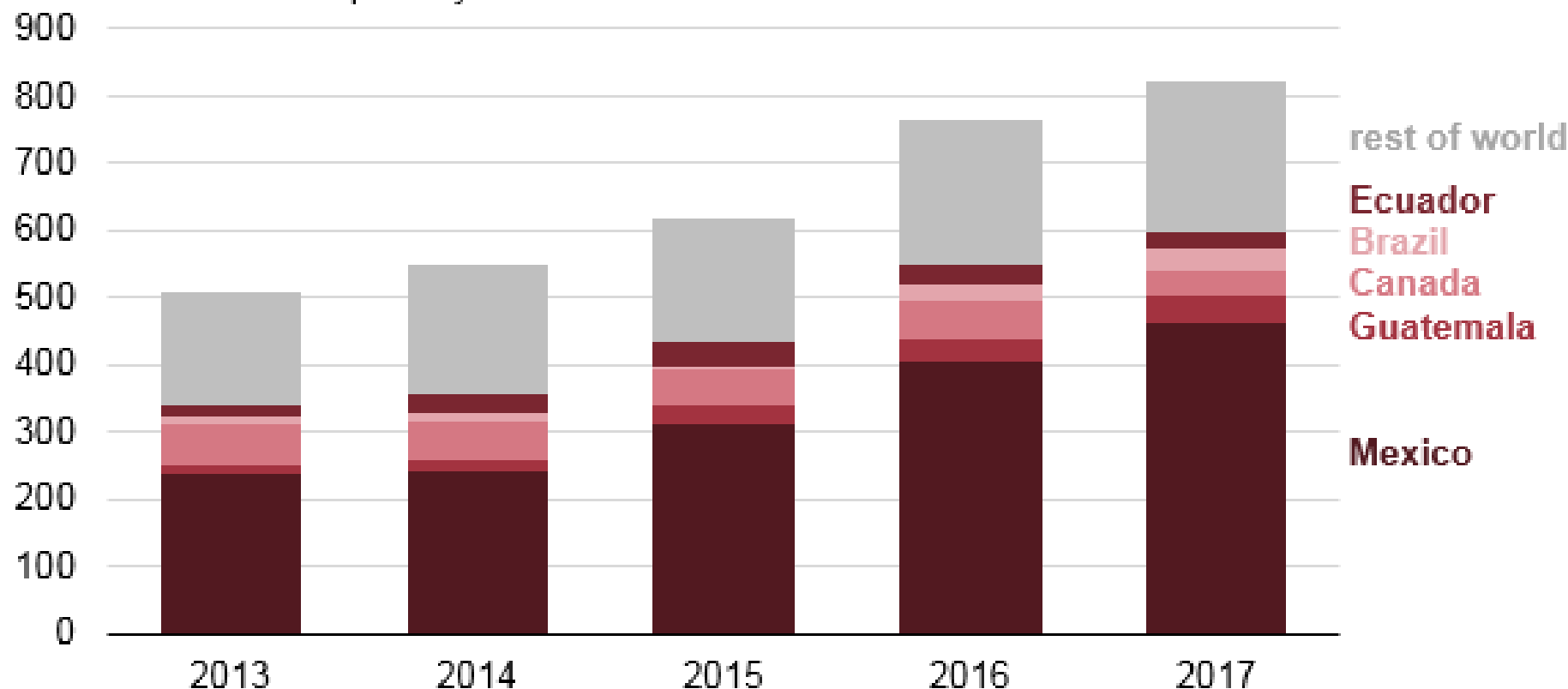


oil markets



EIA: Motor gasoline exports reached new highs in 2017; half of this is exported to Mexico

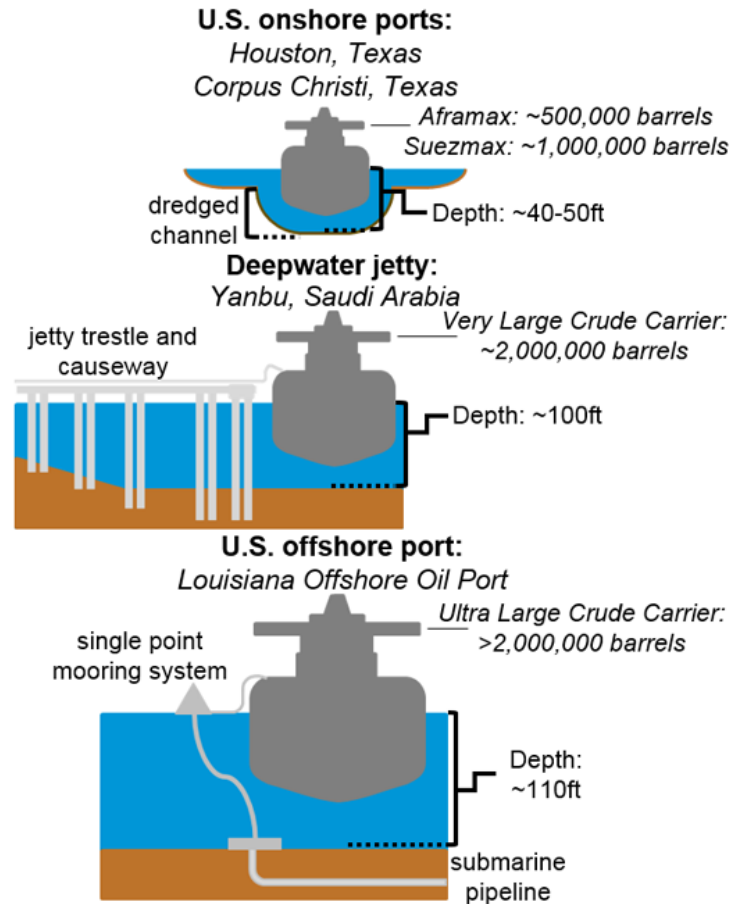
U.S. motor gasoline exports (2013-2017)
thousands of barrels per day



oil markets

EIA: Onshore ports in the United States are not sufficient for largest and most economic ships

Figure 3: Port depth and crude oil export facility examples

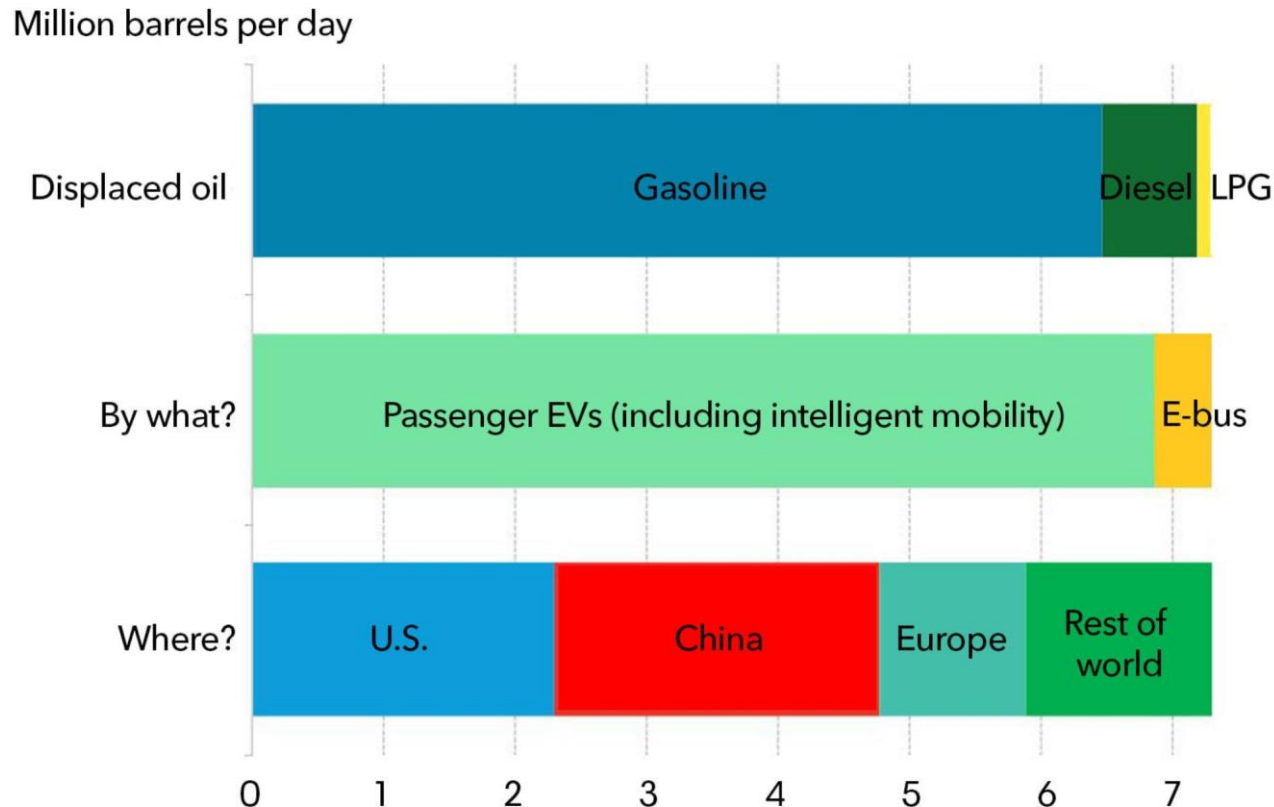


Source: U.S. Energy Information Administration, Saudi Aramco, Louisiana Offshore Oil Port

oil consumption

BNEF: Electrification of cars and buses will displace 7 million barrels of petroleum per day by 2040

Oil displaced due to electrification in 2040



Source: Bloomberg New Energy Finance

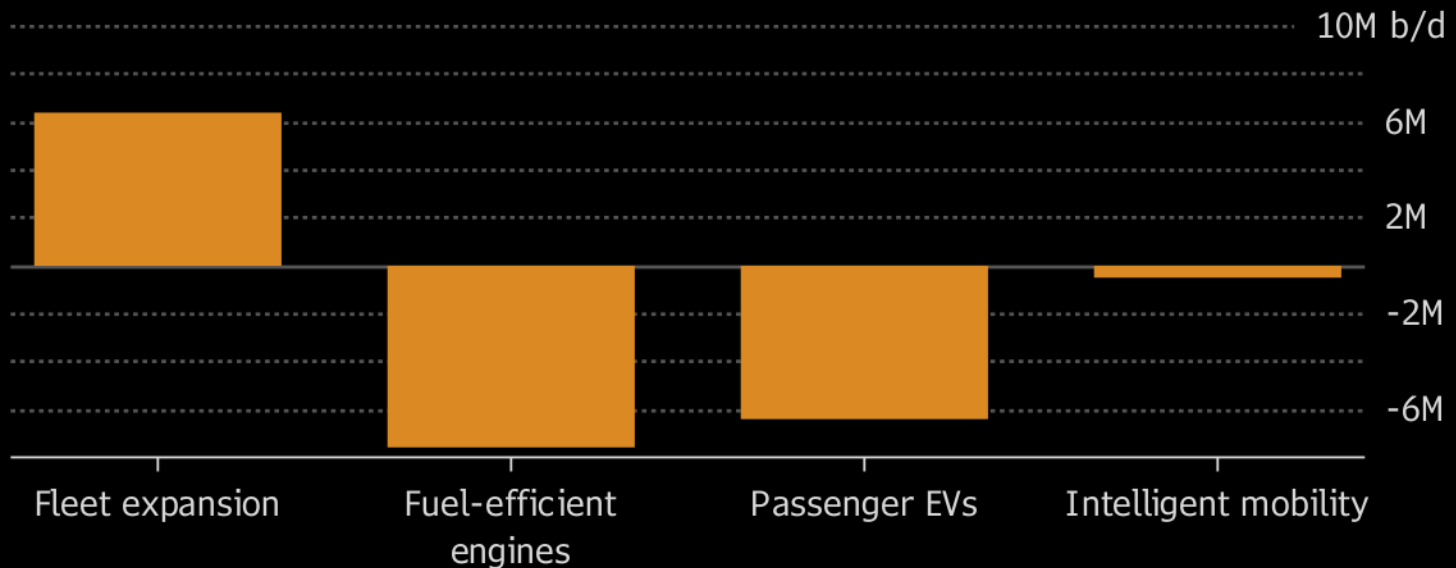
oil consumption

BNEF: Fuel-efficient engines and plug-in vehicles will displace 8 million barrels/day of fuel usage worldwide

Out of Favor

BNEF sees oil use by cars falling to 15.9m b/d by 2040 from 24m b/d now

■ Change in oil demand



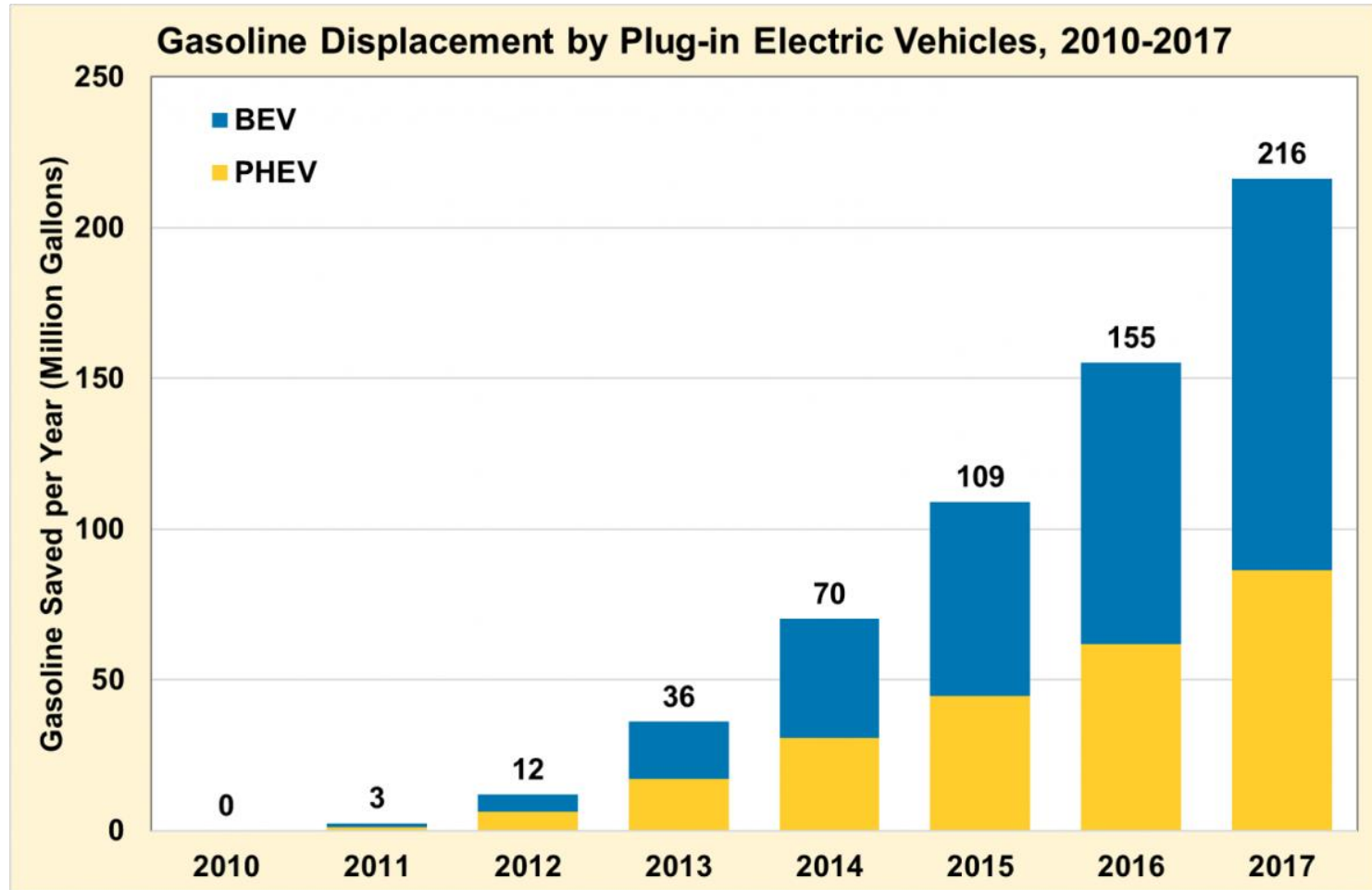
Note: Excludes buses and two-wheel vehicles

Source: Bloomberg New Energy Finance

Bloomberg

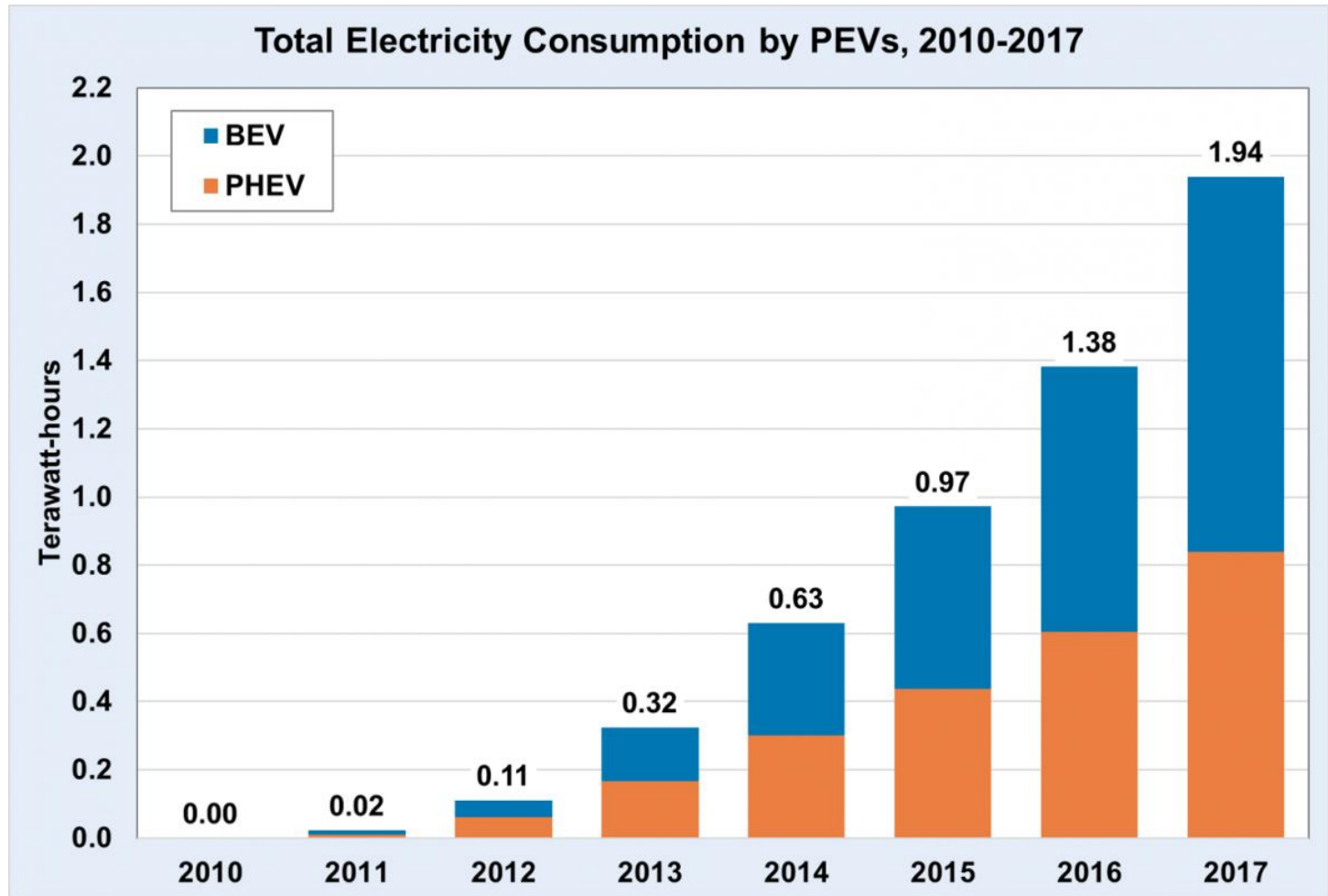
oil consumption

FOTW: Plug-in vehicles displaced over 200 million gallons of gasoline in the U.S. in 2017



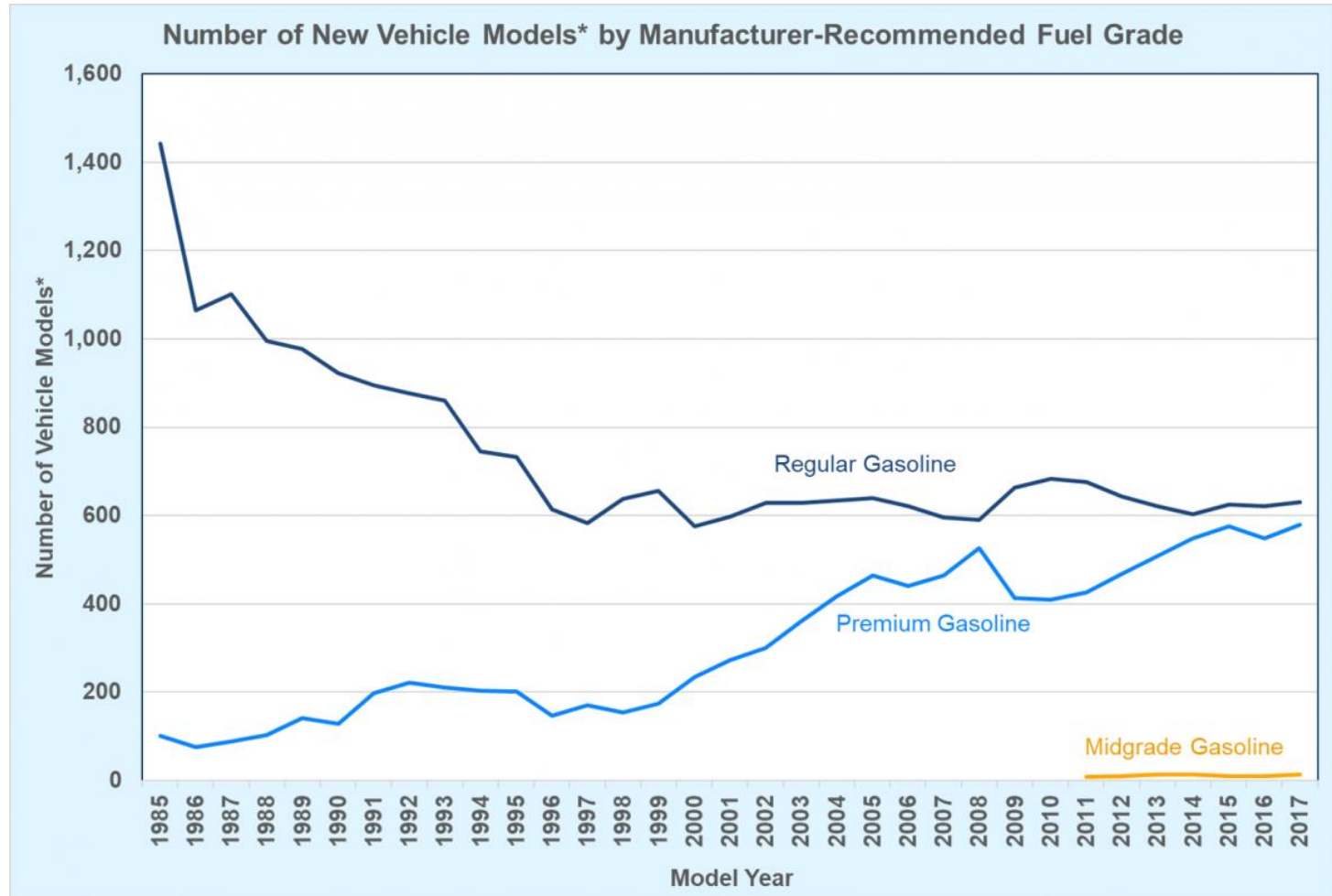
electricity consumption

FOTW: Plug-in vehicles consumed nearly 2 terawatt-hours of electricity in the U.S. in 2017



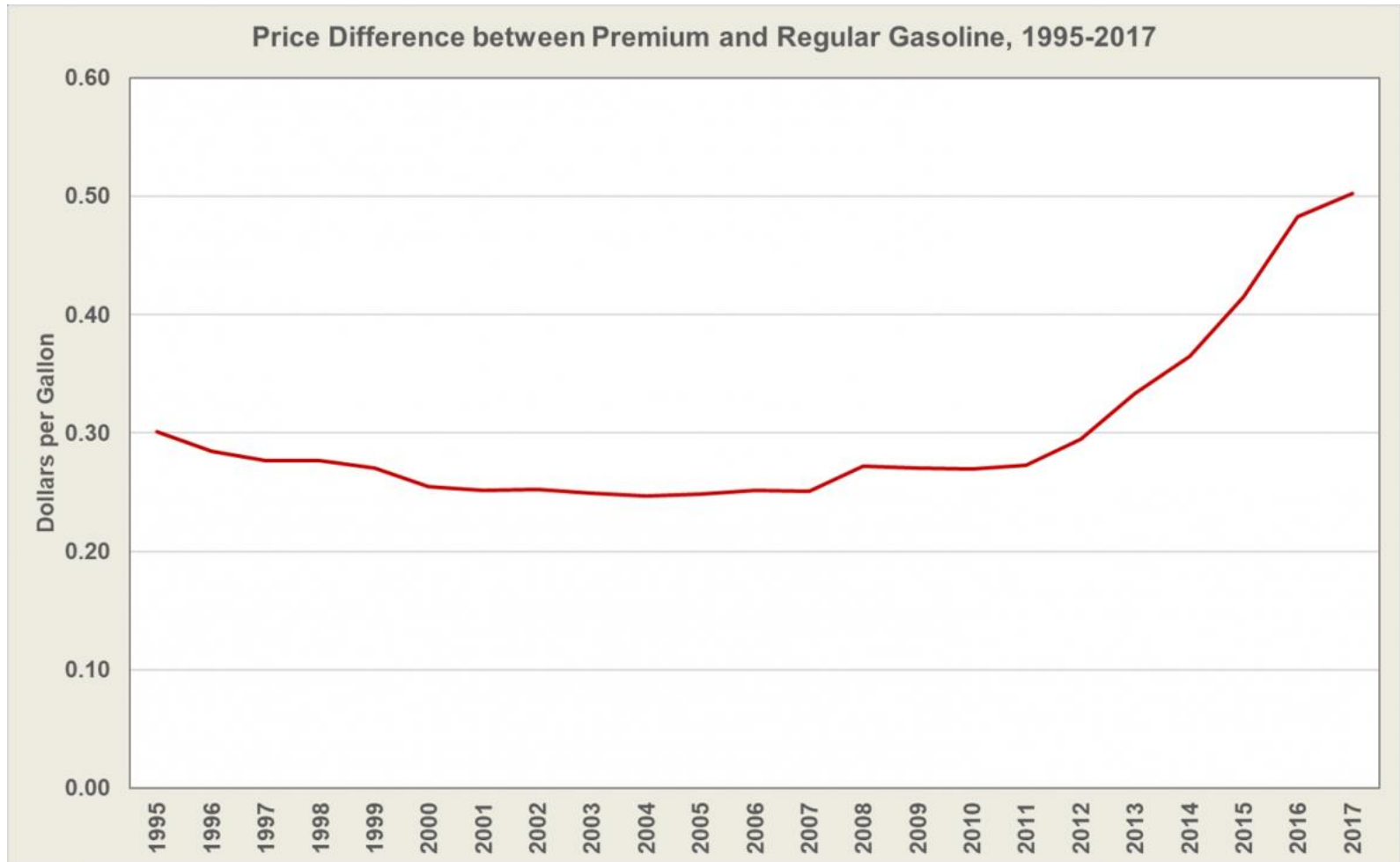
high-octane fuels

FOTW: Manufacturers recommend premium gasoline for nearly half of MY2017 vehicles



high-octane fuels

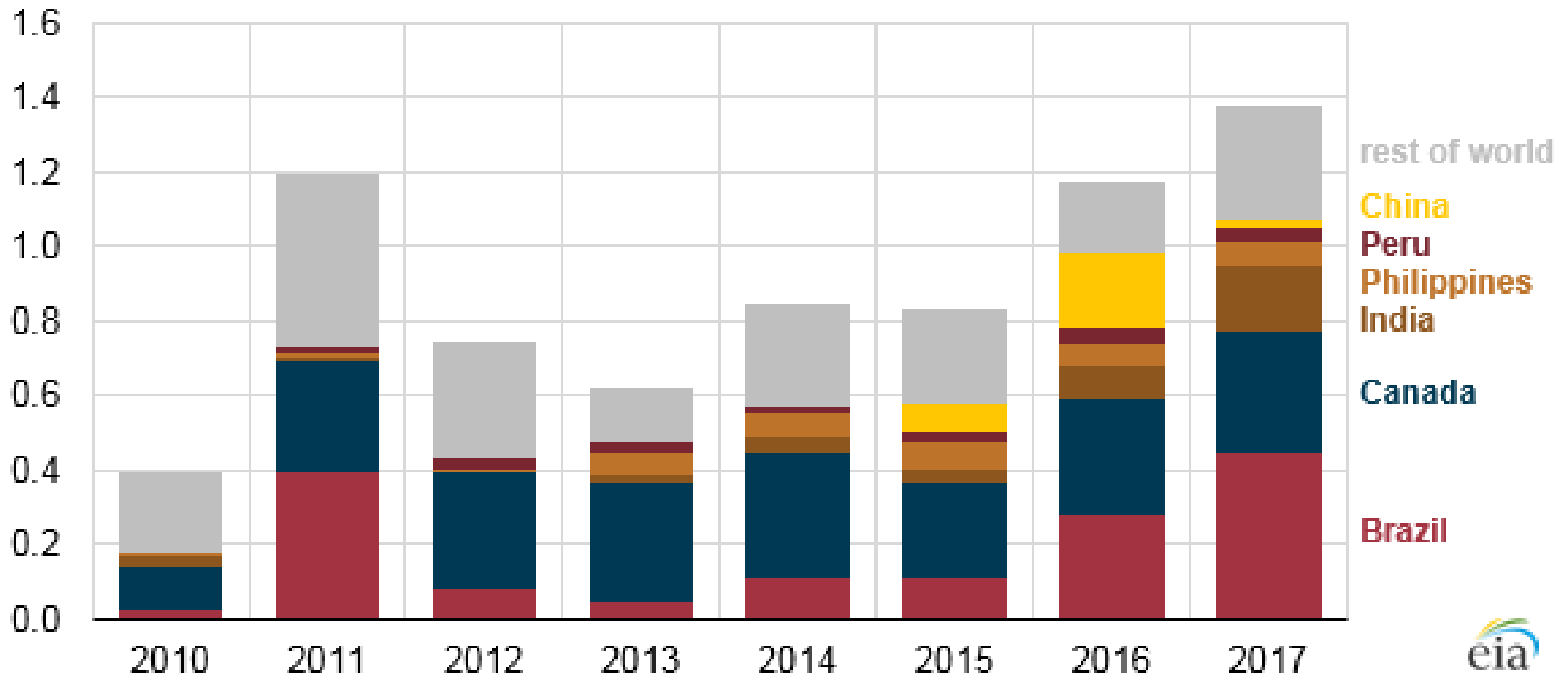
FOTW: The price of premium gasoline is now 50 cents/gallon higher than regular gasoline



high-octane fuels

EIA: The United States exported a record amount of fuel ethanol in 2017

U.S. annual fuel ethanol exports by destination (2010-2017)
billion gallons

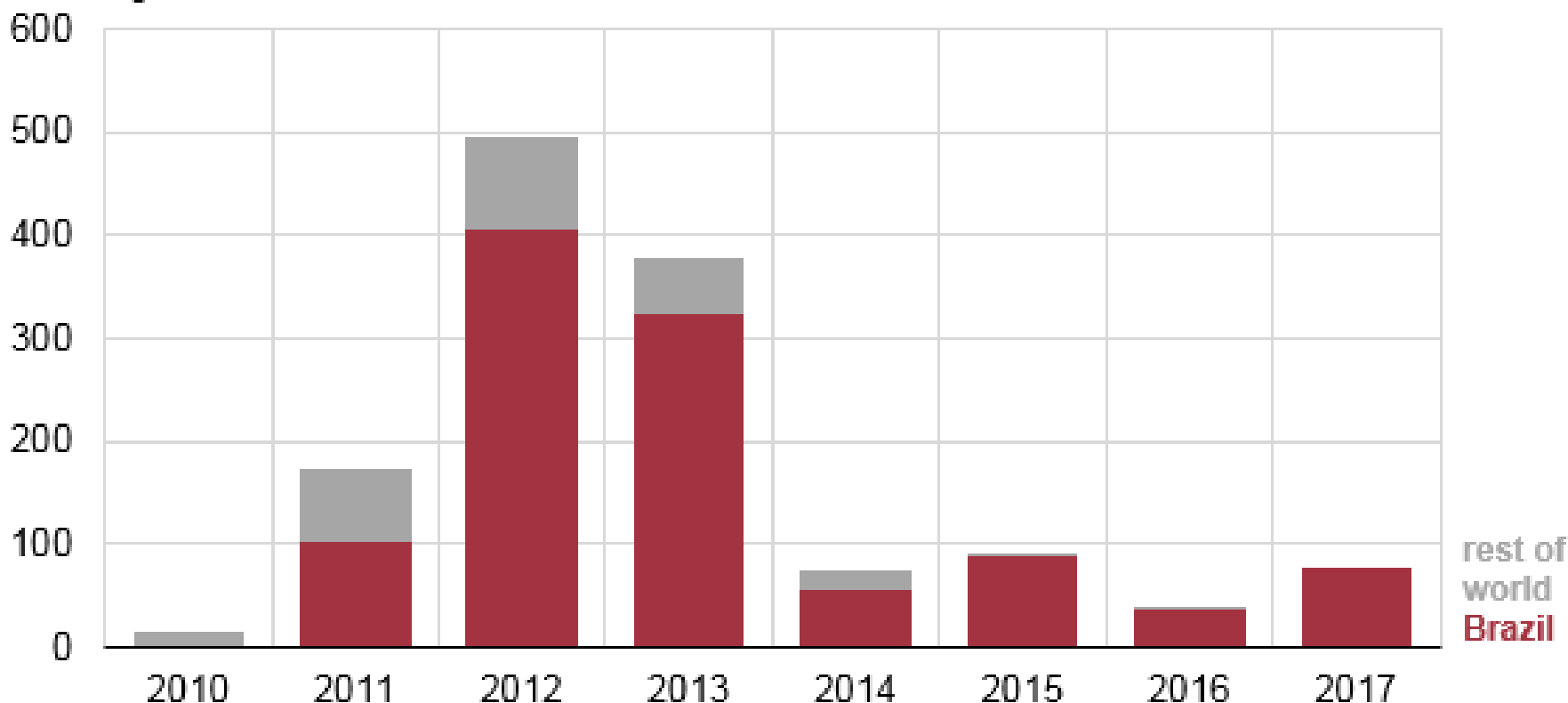


high-octane fuels

EIA: All ethanol imports in 2017 came from Brazil, largely to satisfy California LCFS gasoline targets

U.S. annual fuel ethanol imports by source (2010-2017)

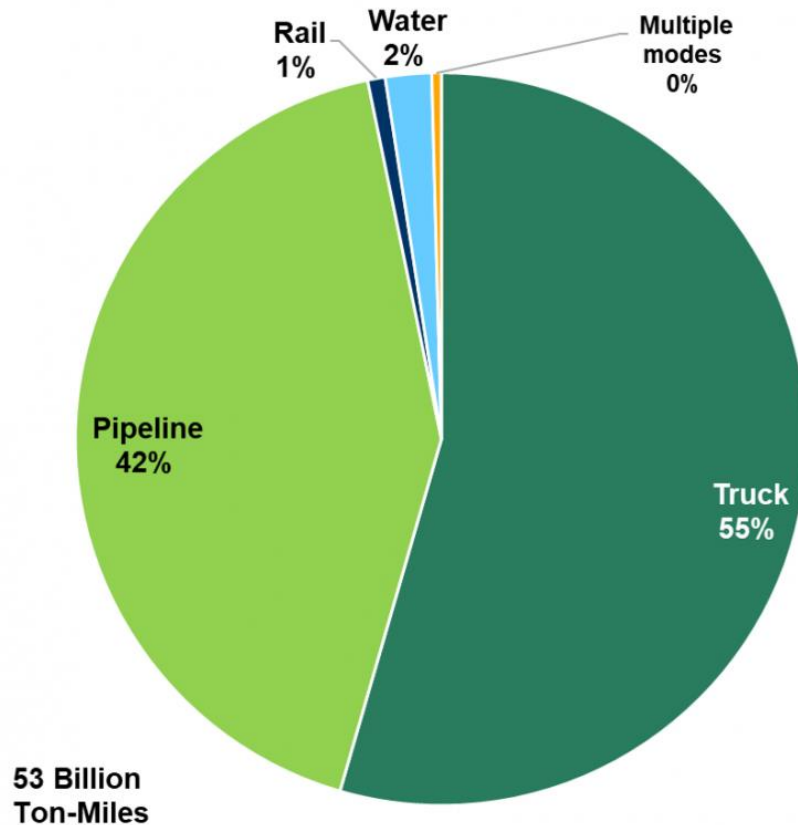
million gallons



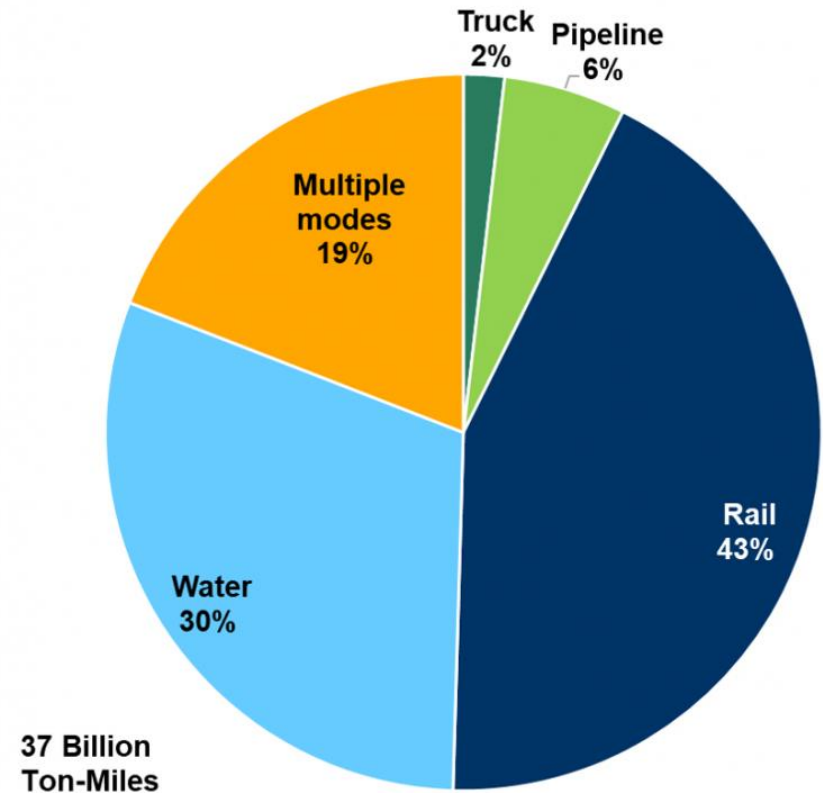
fuel logistics

FOTW: Short-haul gasoline movement is typically done by truck and pipeline, while long haul uses rail and boat

Short-Haul Gasoline Movement, 2015
(<250 Miles)



Long-Haul Gasoline Movement, 2015
(1,000 Miles and Over)



topics

energy markets

2 automotive markets

technologies studies

environmental studies

behavior & opinion surveys

policy & business studies

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outline

2 automotive markets

LDV market

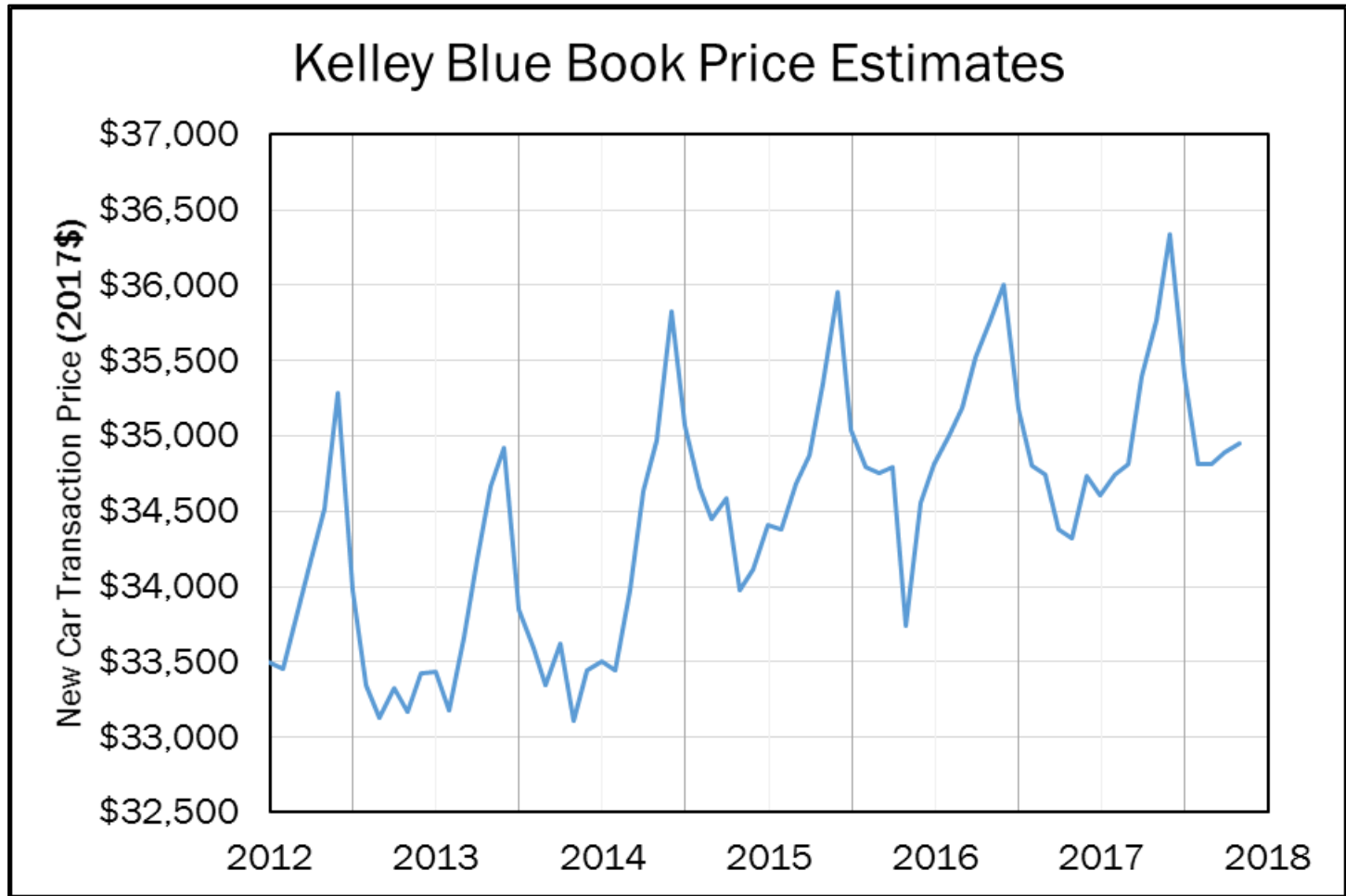
- > KBB: New vehicle prices (inflation adjusted) have increased ~5% since 2012

PEV market

- > EV Sales: Sales of plug-in electric vehicles in Norway surpassed 50% of the entire new LDV market in March

vehicle prices

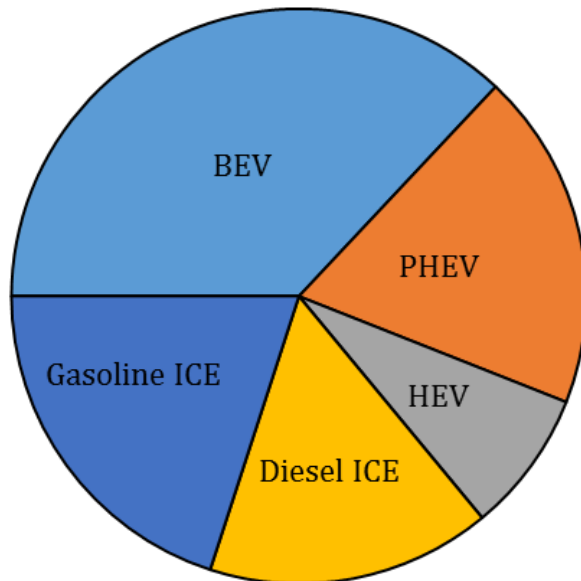
KBB: After adjusting for inflation, new light-duty vehicle prices have increased 5% in last six years



PEV market

EV Sales: PEV sales reached over half of Norwegian market in March 2018; no pure ICE in top-ten sales

Market Share by Powertrain
Norway, March 2018



■ BEV ■ PHEV ■ HEV ■ Diesel ICE ■ Gasoline ICE

Vehicle	Powertrain	Sales
Nissan Leaf	BEV	2172
Tesla Model X	BEV	727
Tesla Model S	BEV	676
BMW i3	BEV/PHEV	528
Mit. Outlander PHEV	PHEV	438
VW e-Golf	BEV	433
Volvo S/V90 PHEV	PHEV	394
Renault Zoe	BEV	347
Volvo XC60 PHEV	PHEV	314
Toyota RAV4	HEV	295

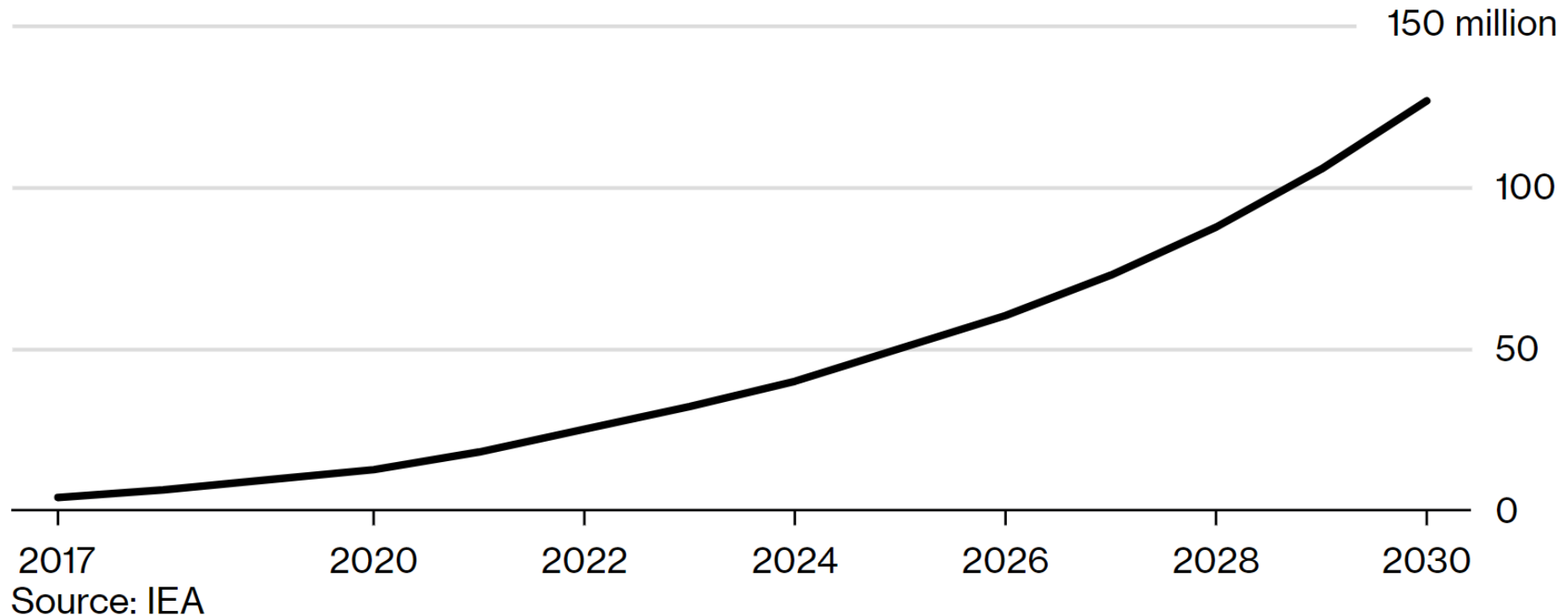
PEV forecasts



IEA via Bloomberg: The global fleet of PEVs will triple to 13 million by the end of the decade

Electric Boom

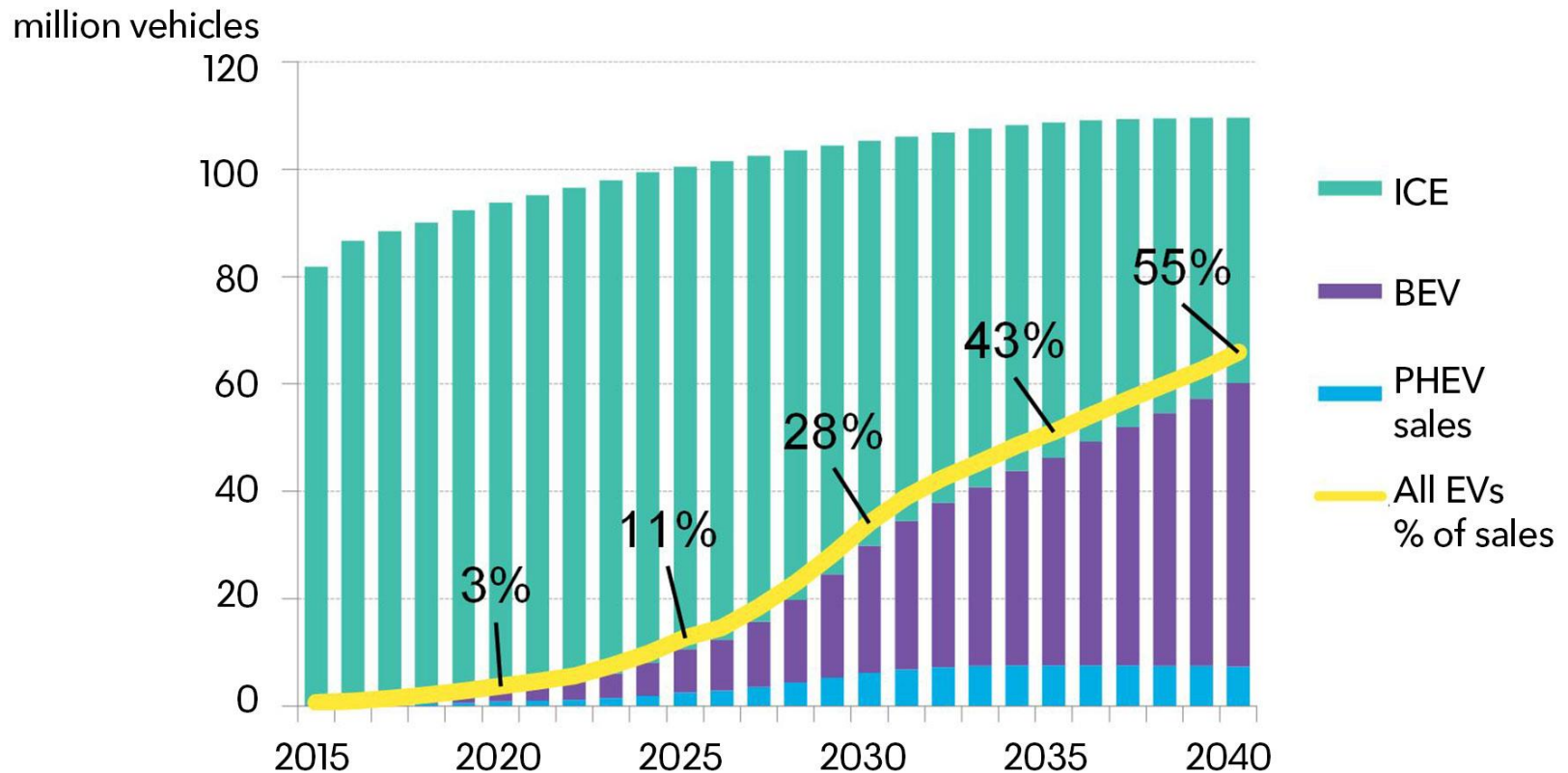
The global fleet of electric vehicles is set to soar



PEV forecasts

BNEF: PEVs will be more than half of global LDV sales by 2040

Annual global light duty vehicle sales



Source: Bloomberg New Energy Finance

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automotive markets

3 technologies studies

environmental studies

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policy & business studies

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3 technologies studies

vehicle technologies

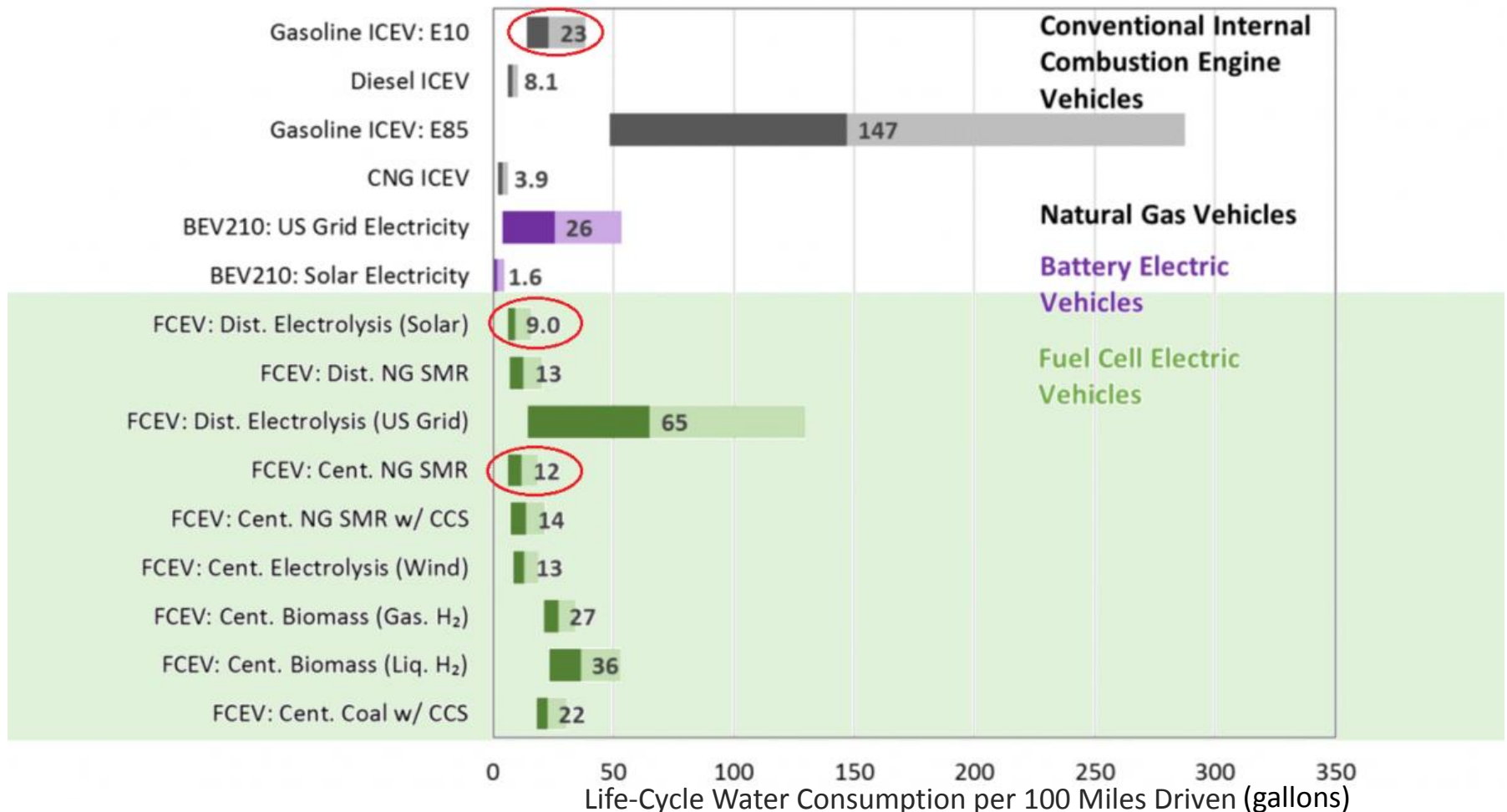
- > FCTO: Fuel cell vehicles can have half the lifecycle water consumption as ICE vehicles

CAVs

- > EIA: Autonomous vehicles could reduce LDV energy usage by over 10%

water consumption

FCTO: Life-cycle water consumption of fuel cell vehicles can be half of conventional ICE vehicles

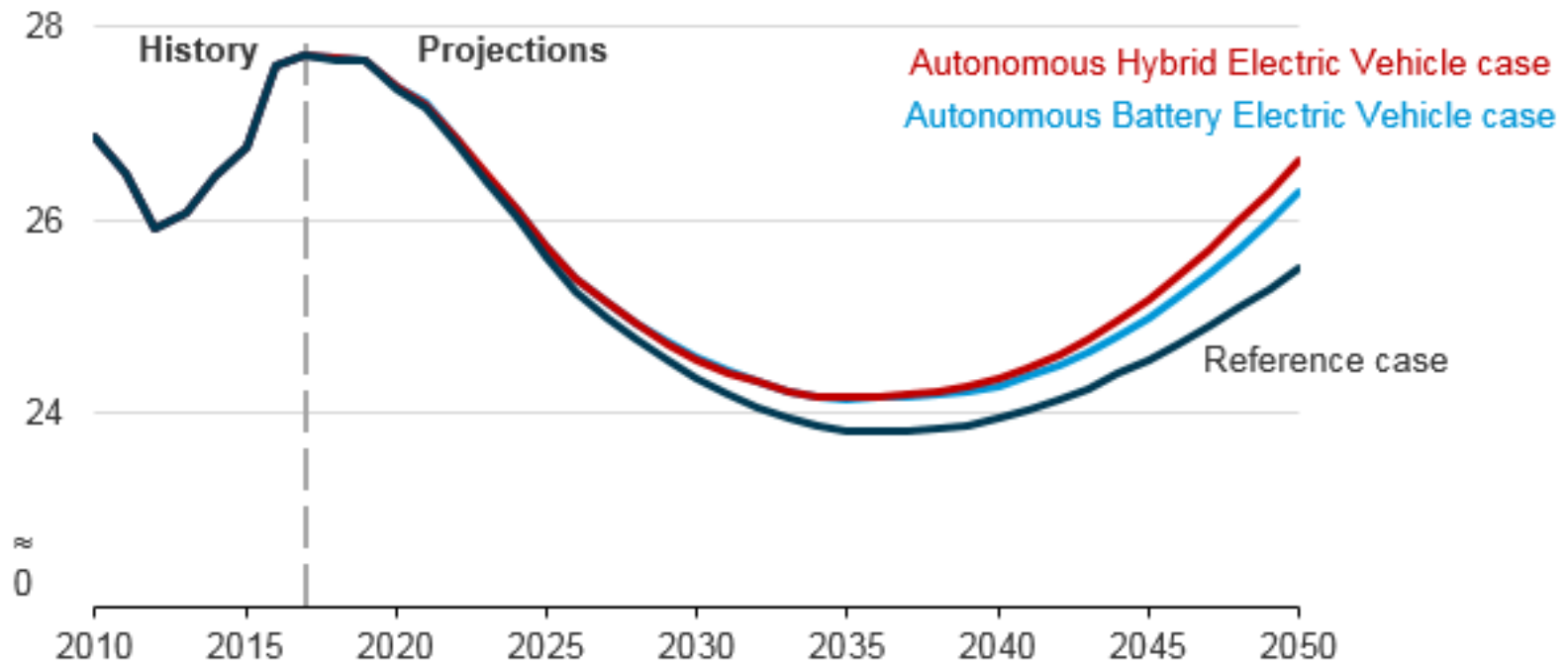


CAVs

EIA: Use of autonomous vehicles could increase transportation energy consumption by over 10%

Figure 2. Transportation energy consumption in three cases, 2010-2050

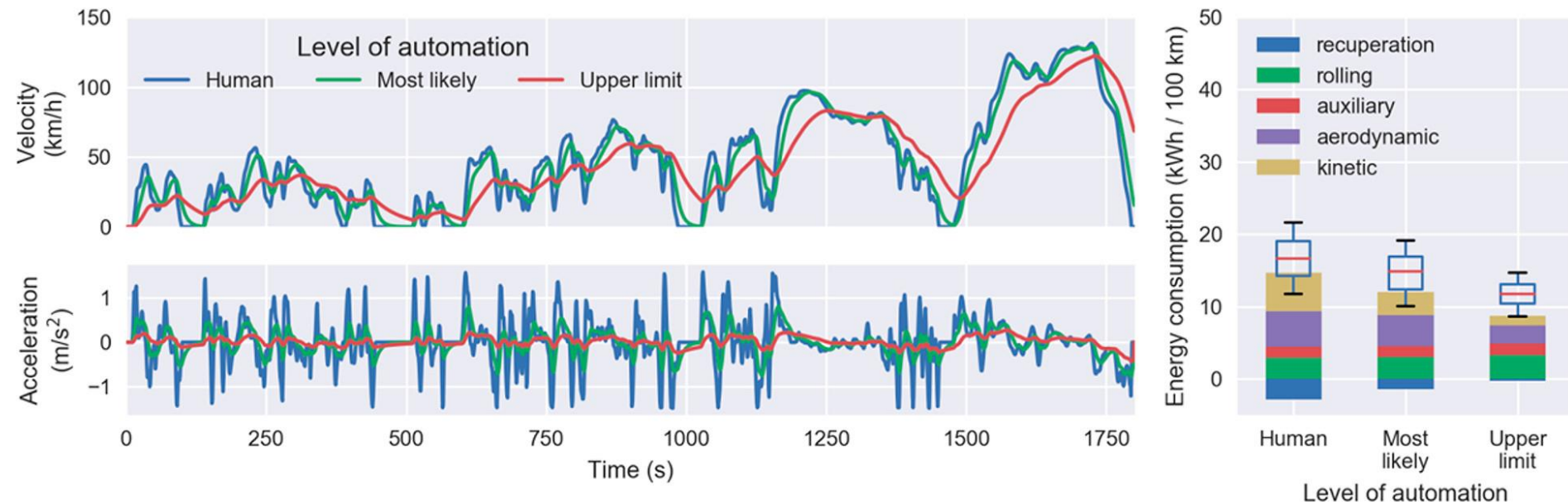
Transportation energy consumption
quadrillion Btu



Source: U.S. Energy Information Administration, *Annual Energy Outlook 2018*

CAVs

PSI/Leiden: Smoothing of drive cycles is likely to lead to a 10% improvement in fuel economy for (BEV) CAVs



topics

energy markets

automotive markets

technologies studies

4 environmental studies

behavior & opinion surveys

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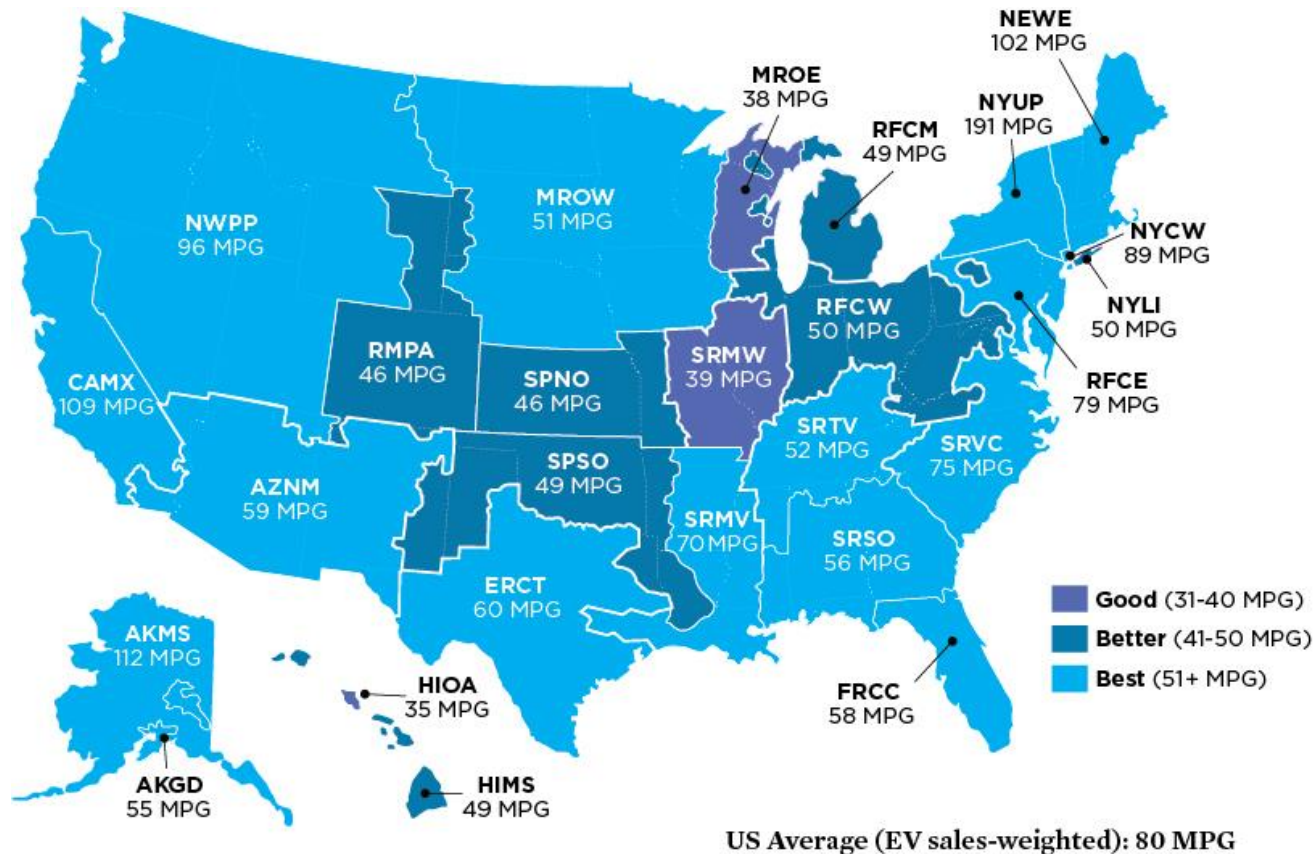
4 environmental studies

emissions

- > UCS: A typical BEV emits far lower CO₂ than an average ICE vehicle

emissions

UCS: A typical BEV is equivalent to an ICE vehicle at 80mpg, from emissions perspective



Note: The MPG (miles per gallon) value listed for each region is the combined city/highway fuel economy rating of a gasoline vehicle that would have global warming emissions equivalent to driving an EV. Regional global warming emissions ratings are based on 2016 power plant data in the EPA's eGRID 2016 database (the most recent version). Comparisons include gasoline and electricity fuel production emissions estimates using Argonne National Laboratory's GREET 2017 model. The 80 MPG US average is a sales-weighted average based on where EVs were sold in 2011-2017.

topics

energy markets

automotive markets

technologies studies

environmental studies

5 behavior & opinion surveys

policy & business studies

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5 behavior & opinion surveys

travel behavior

- > FOTW: GDP as grown faster than VMT for about the last decade
- > FOTW: Half as many commuters carpool as in 1980

mode choice

- > NYC: Half of ride-sharing rides displaced transit in New York
- > NACTO: Bikeshare has grown rapidly in last few years

CAV sentiments

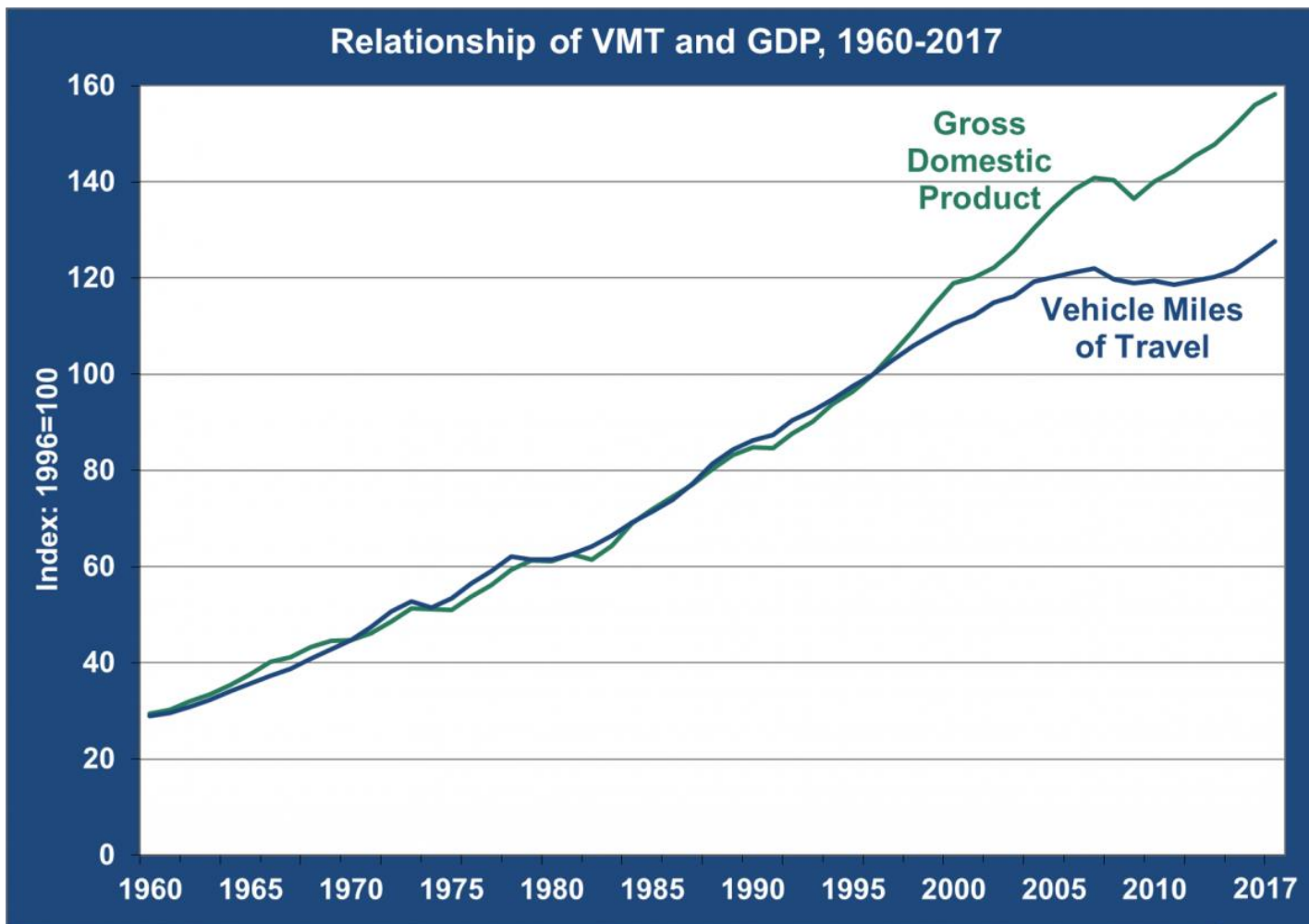
- > Gallup: Half of Americans expect self-driving cars to be common within ten years
- > AAA: Americans of all ages are becoming ~~more~~ less comfortable with CAVs

PEV sentiments

- > AAA: Americans are becoming more interested in owning electric vehicles
- > Axios: Charging infrastructure is viewed as a barrier for electric vehicles

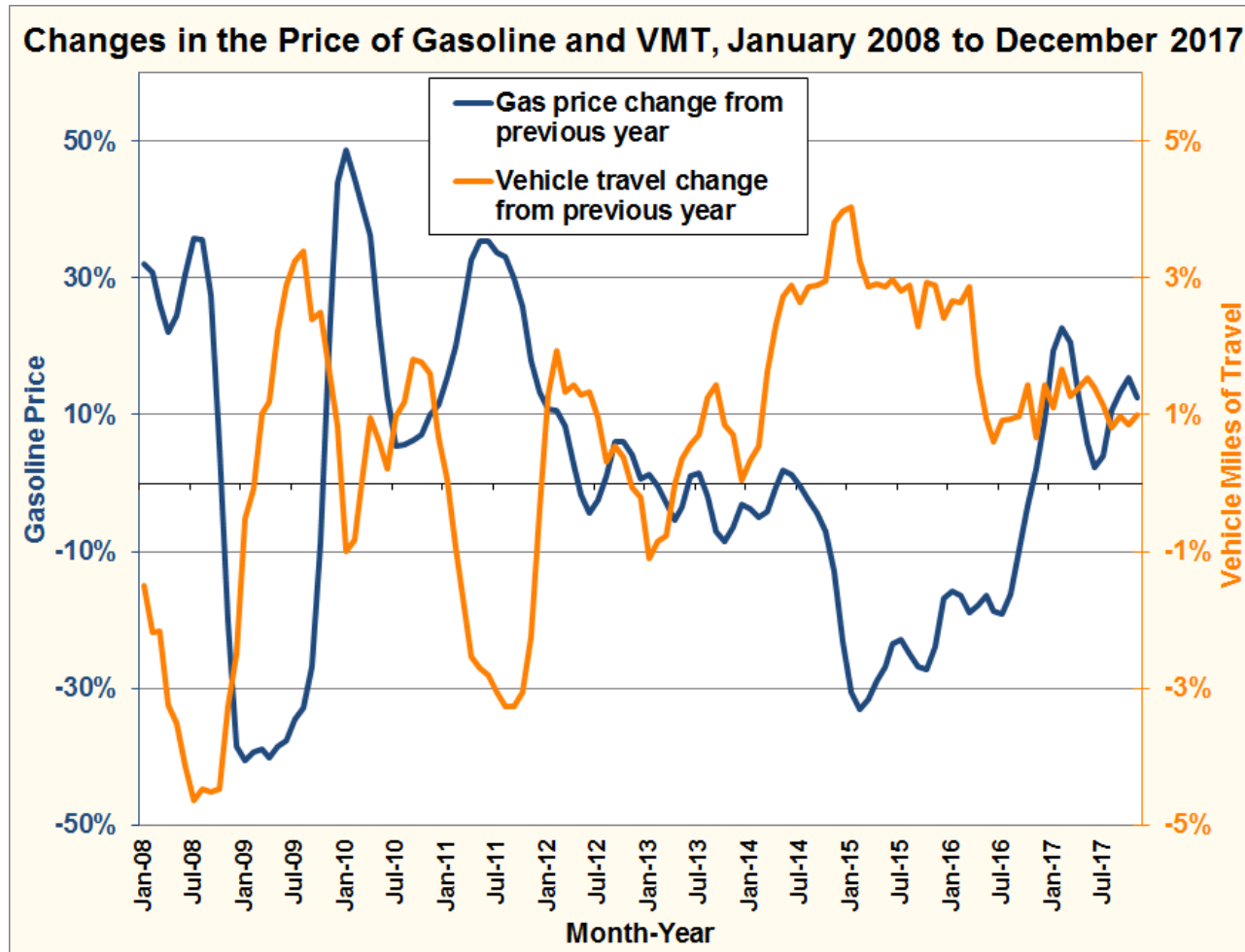
travel behavior

FOTW: Since the mid-1990s, the growth in U.S. GDP has outpaced the growth in VMT



travel behavior

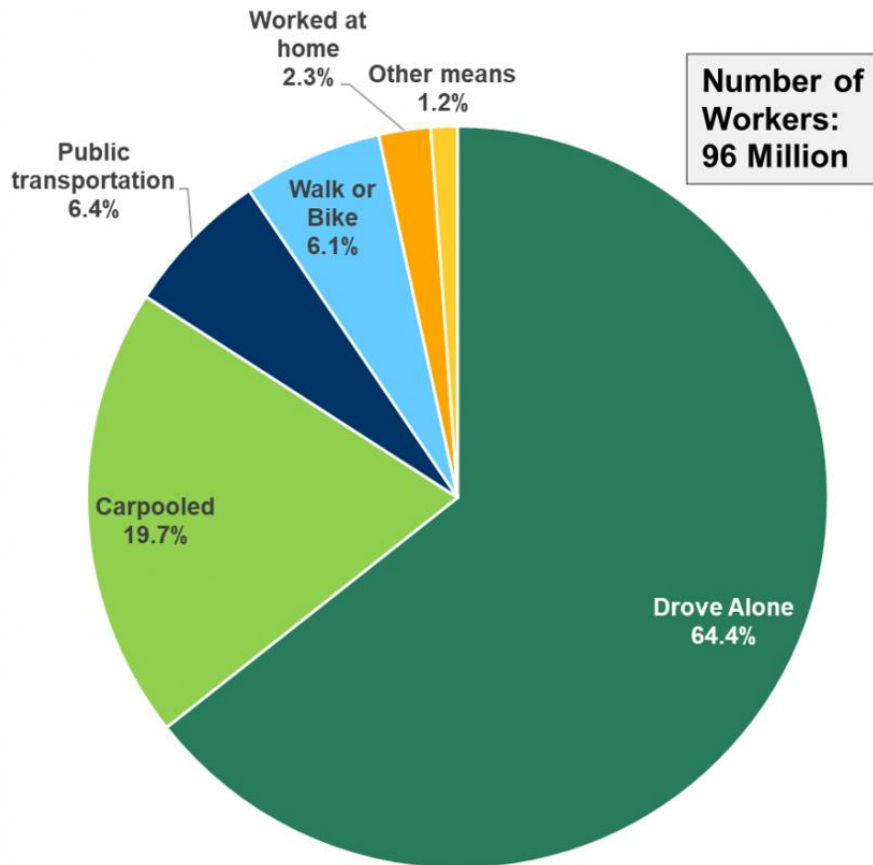
FOTW: Changes in VMT often mirror changes in gasoline price



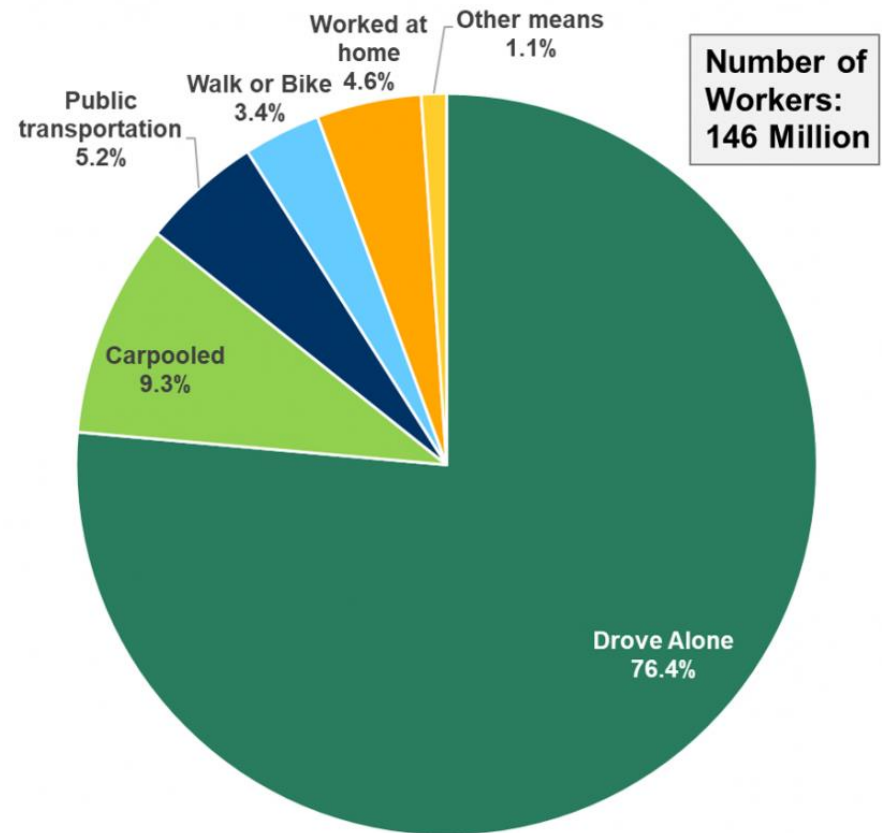
travel behavior

**FOTW: 75% of workers drove alone to work in 2016;
carpooling halved since 1980**

Means of Transportation to Work, 1980

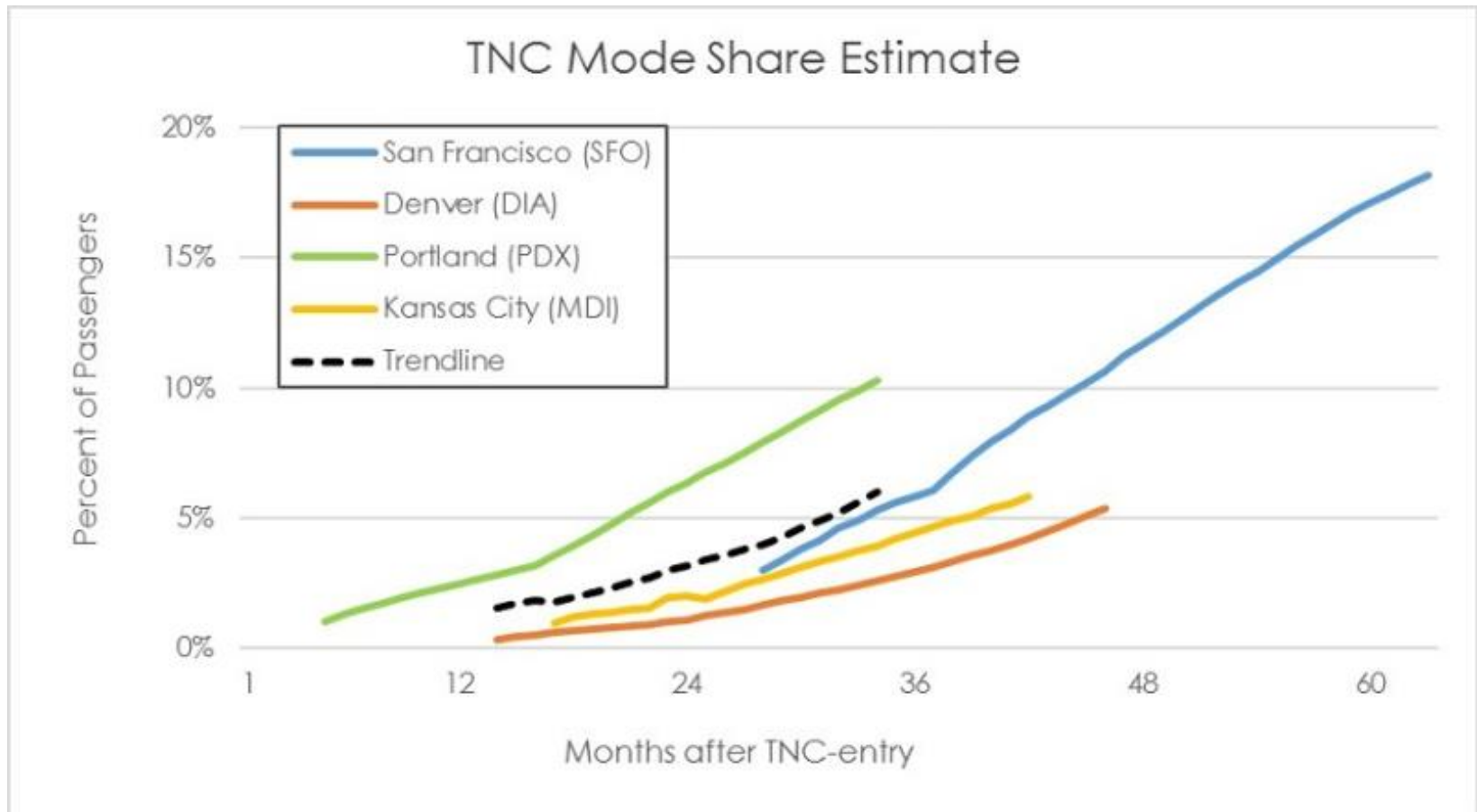


Means of Transportation to Work, 2016



travel behavior

NREL: Ride-hailing is travel mode of choice for an increasing percentage of airport arrivals



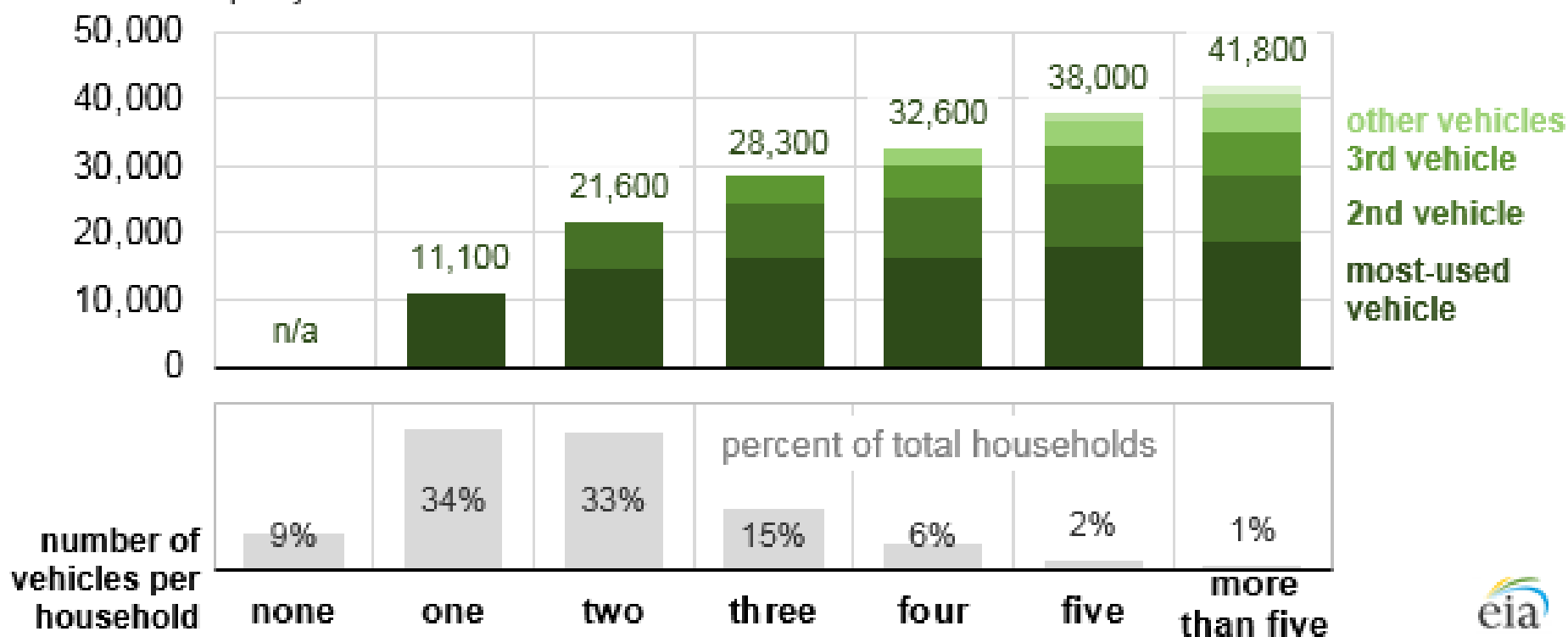
travel behavior



NHTS via EIA: U.S. households with more vehicles travel more but use additional vehicles less

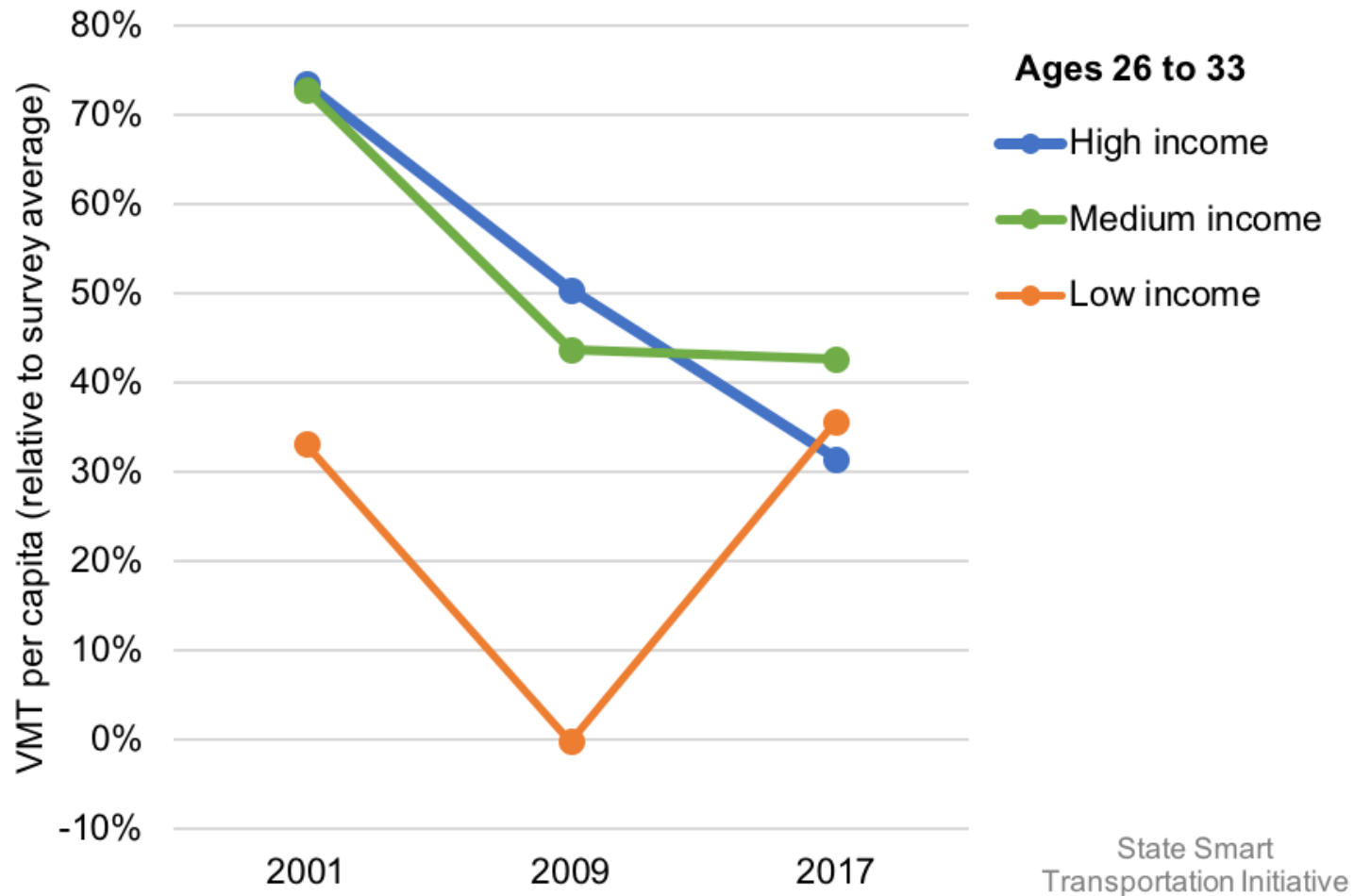
Average annual vehicle miles per household (2017)

vehicle miles per year



travel behavior

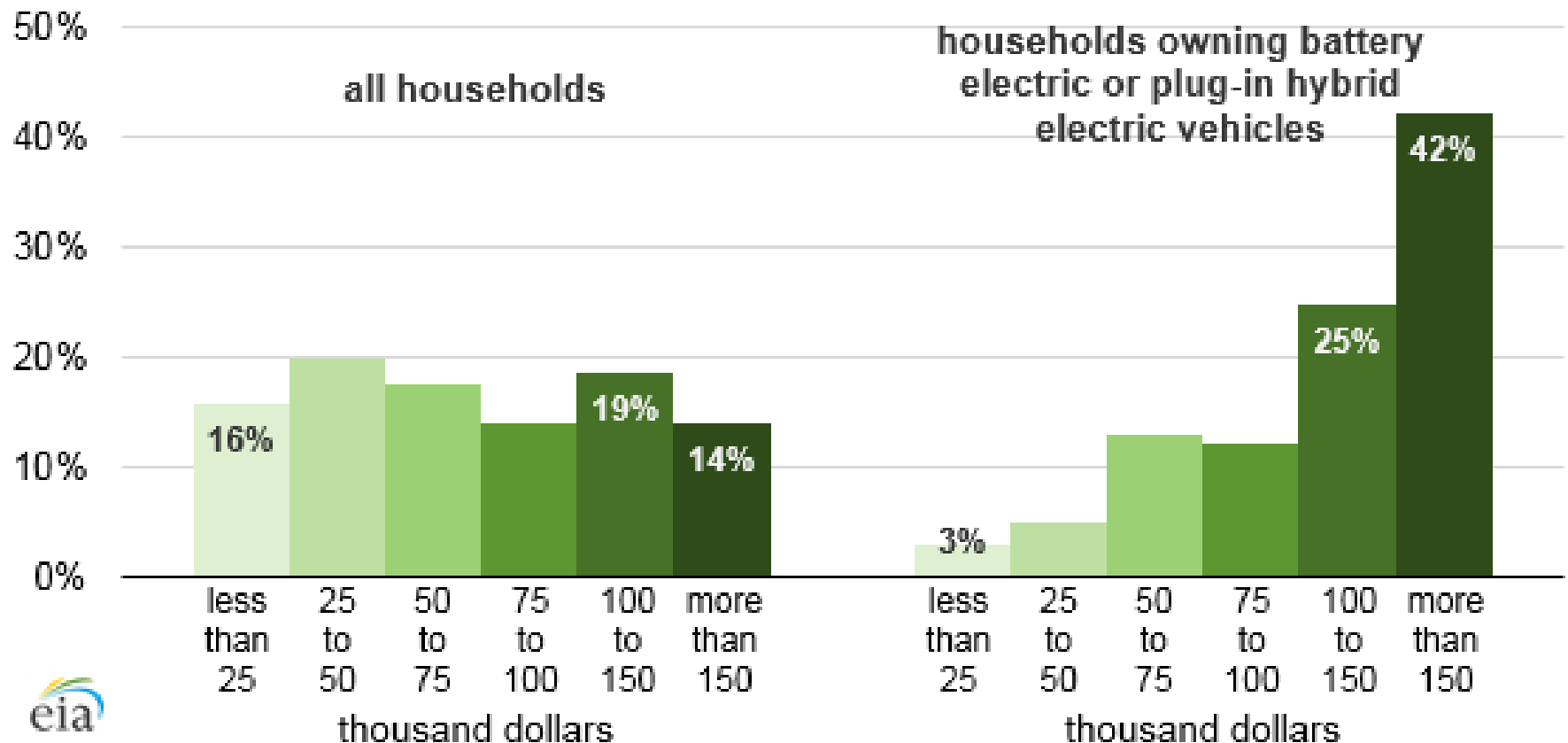
NHTS via SSTI: Young adults across economic spectrum are now driving more than the national average



PEV market

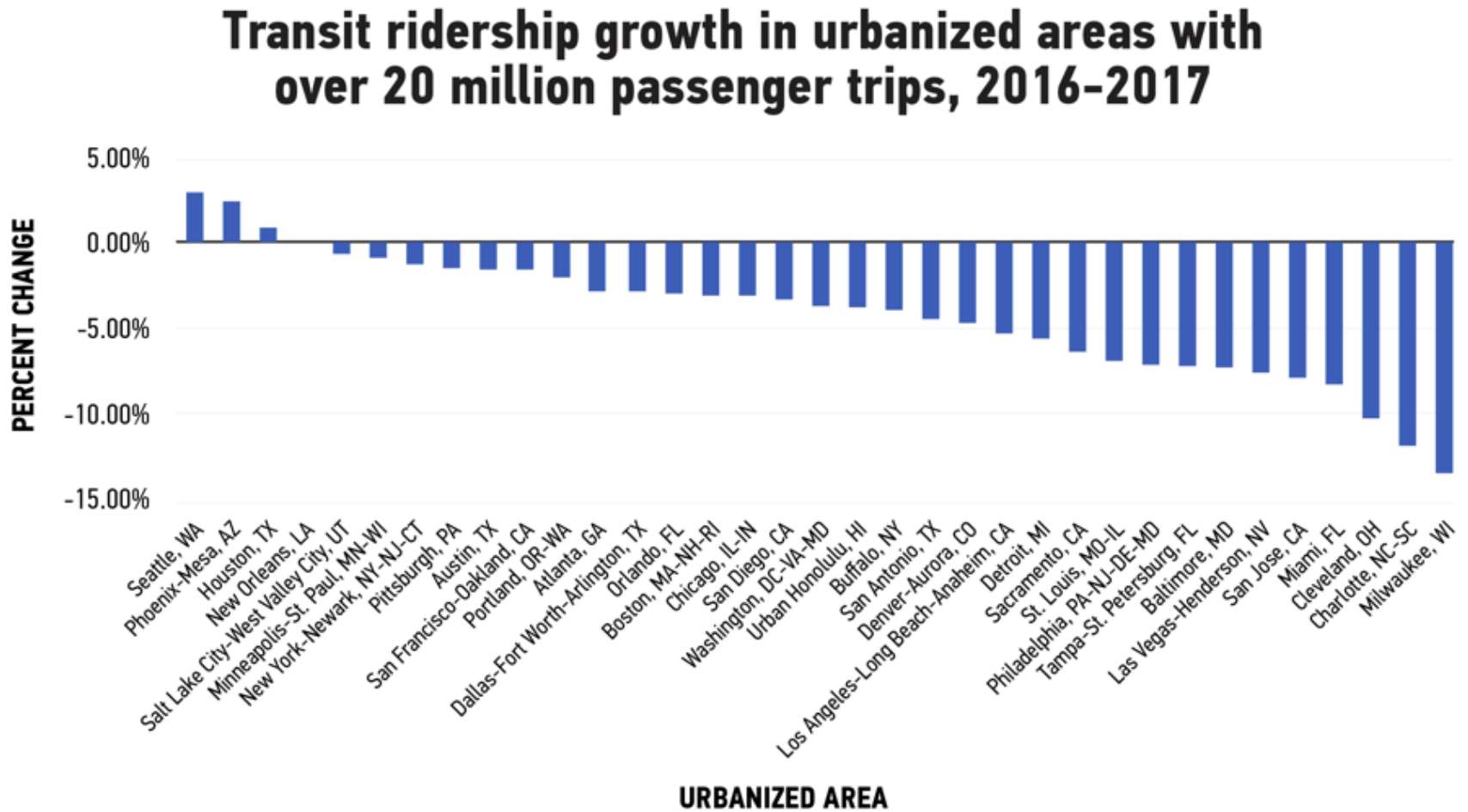
NHTS via EIA: Households with PEVs generally have a higher income than other households

U.S. household income distribution, 2017



mode choice

TransitCenter via CityLab: Transit ridership declined in most major U.S. cities in 2017



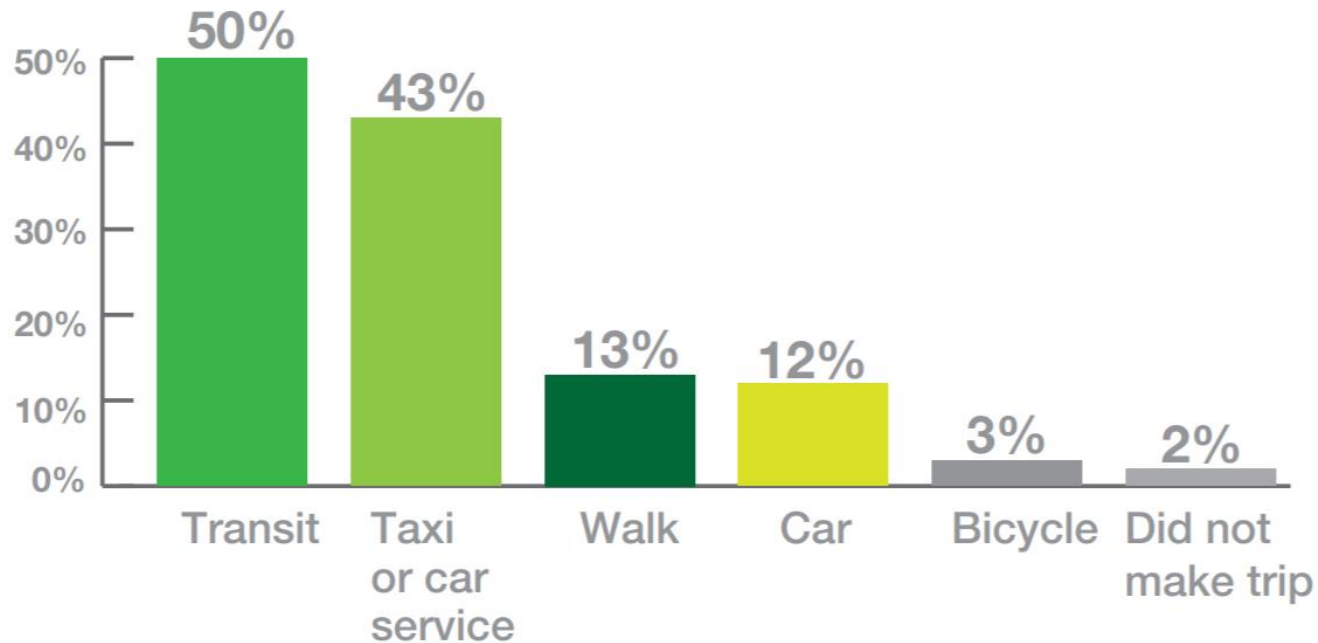
mode choice

NYC: Half of ride-hailing uses in New York were shifted from public transit

Ride-Hail Mode Shift

How would you make this trip if not by ride-hail?

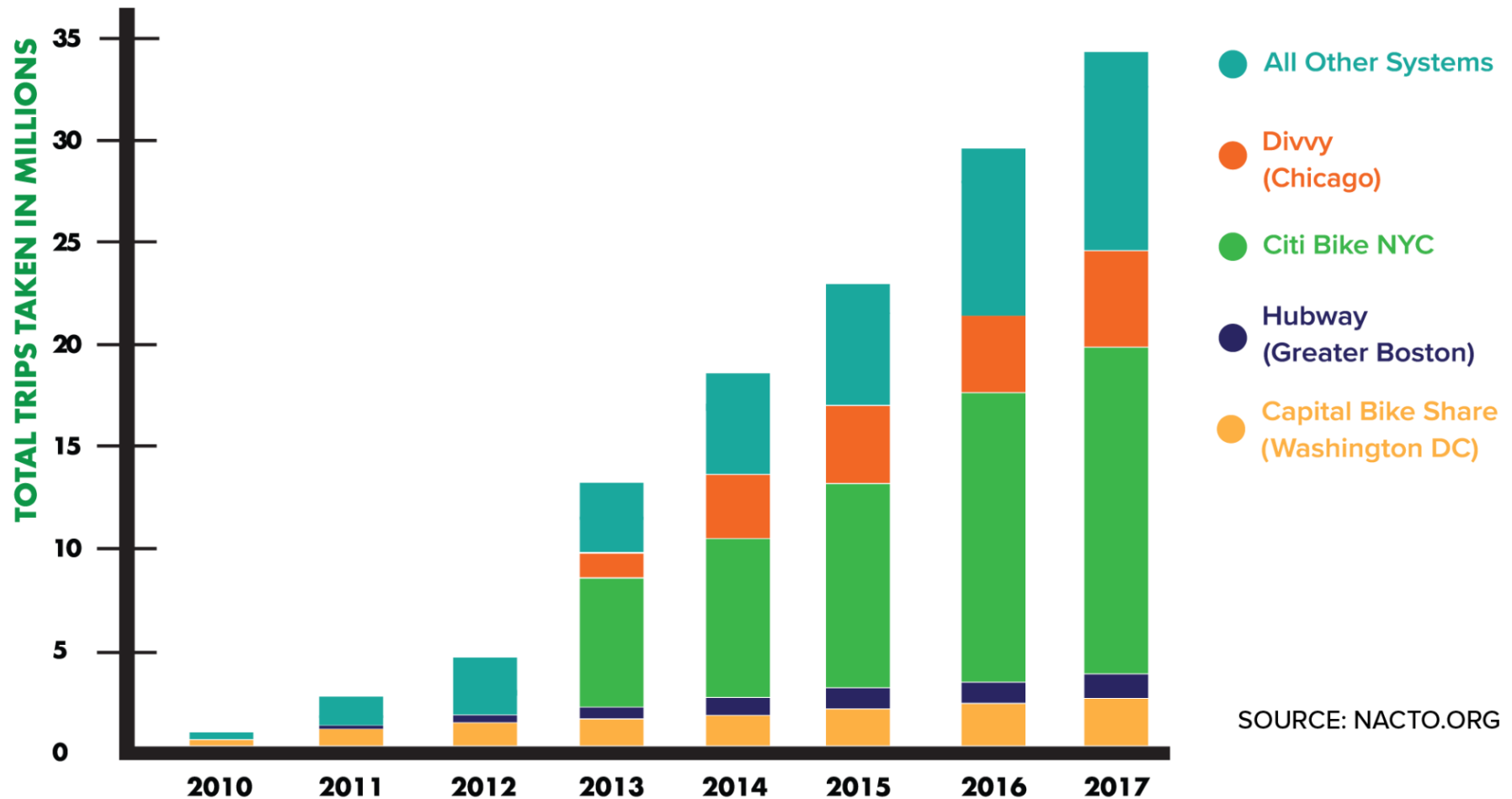
n = 616



*Respondents could select multiple options

mode choice

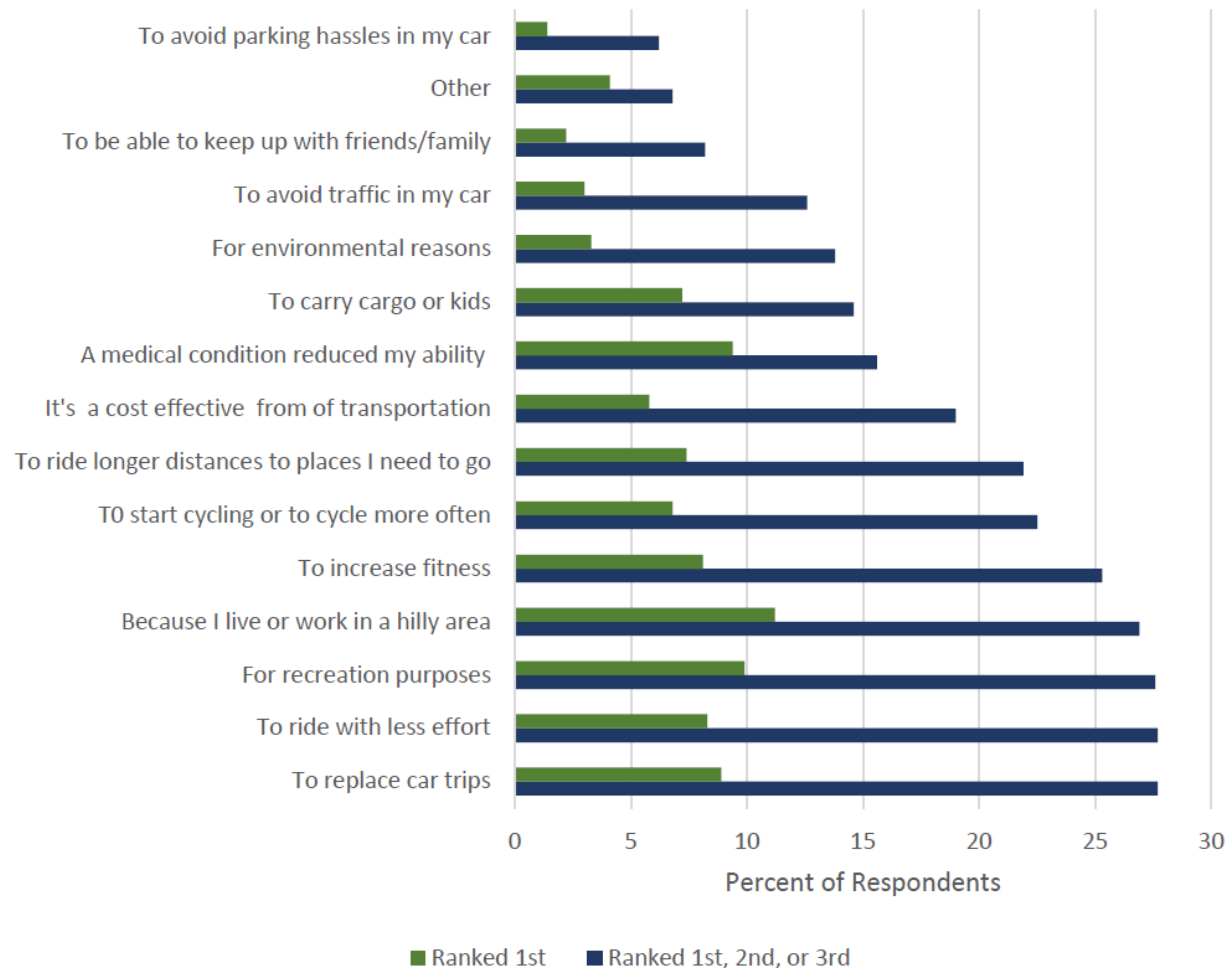
NACTO: Bike share usage in the United States has nearly tripled since 2013



SOURCE: NACTO.ORG

mode choice

NITC: 13% of riders cite replacing car trips, avoiding car traffic, or parking hassles as #1 reason to ride e-bike

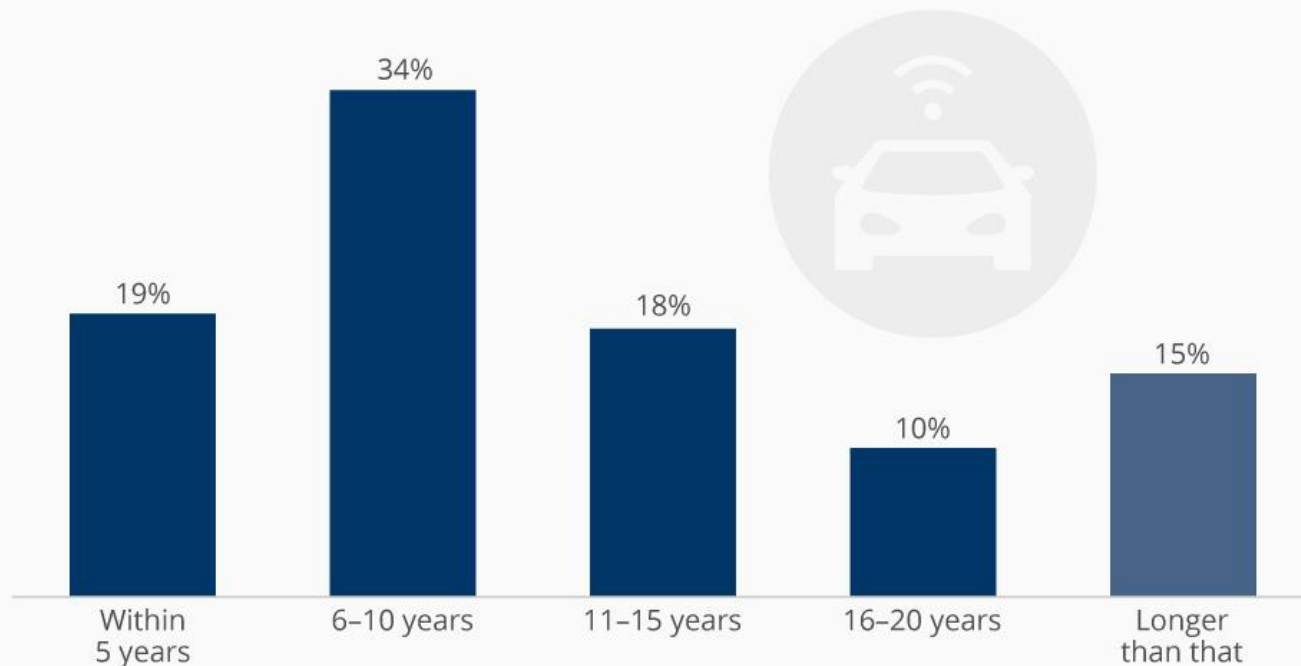


CAV sentiments

Gallup via Statista: Half of Americans expect fully autonomous vehicles to be common within 10 years

Americans Expect Driverless Cars to Be Common in 10 Years

"How soon do you think driverless cars will be commonly used in the U.S.?"

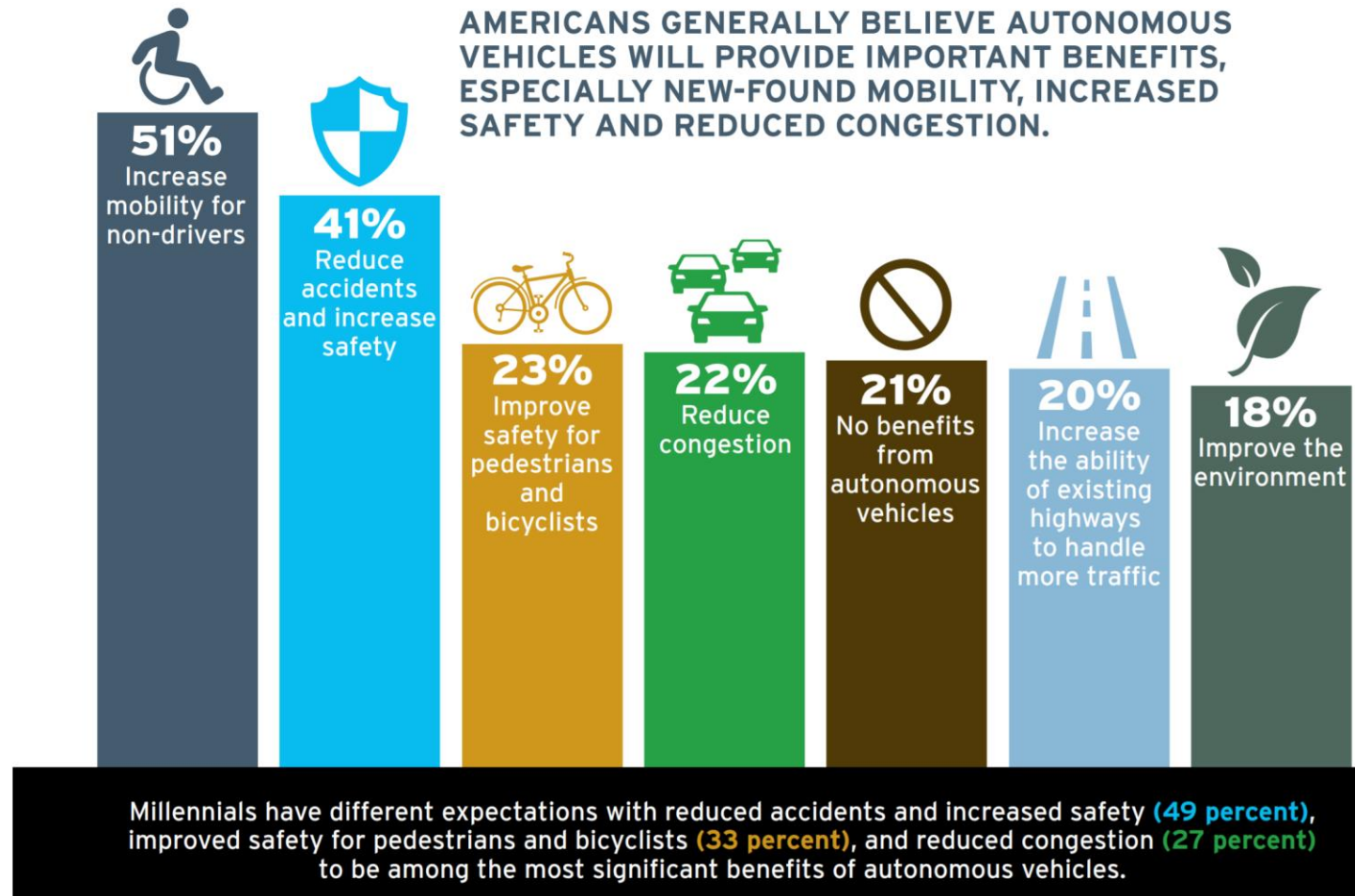


n=1,503 adults, aged 18+
Source: Gallup

statista

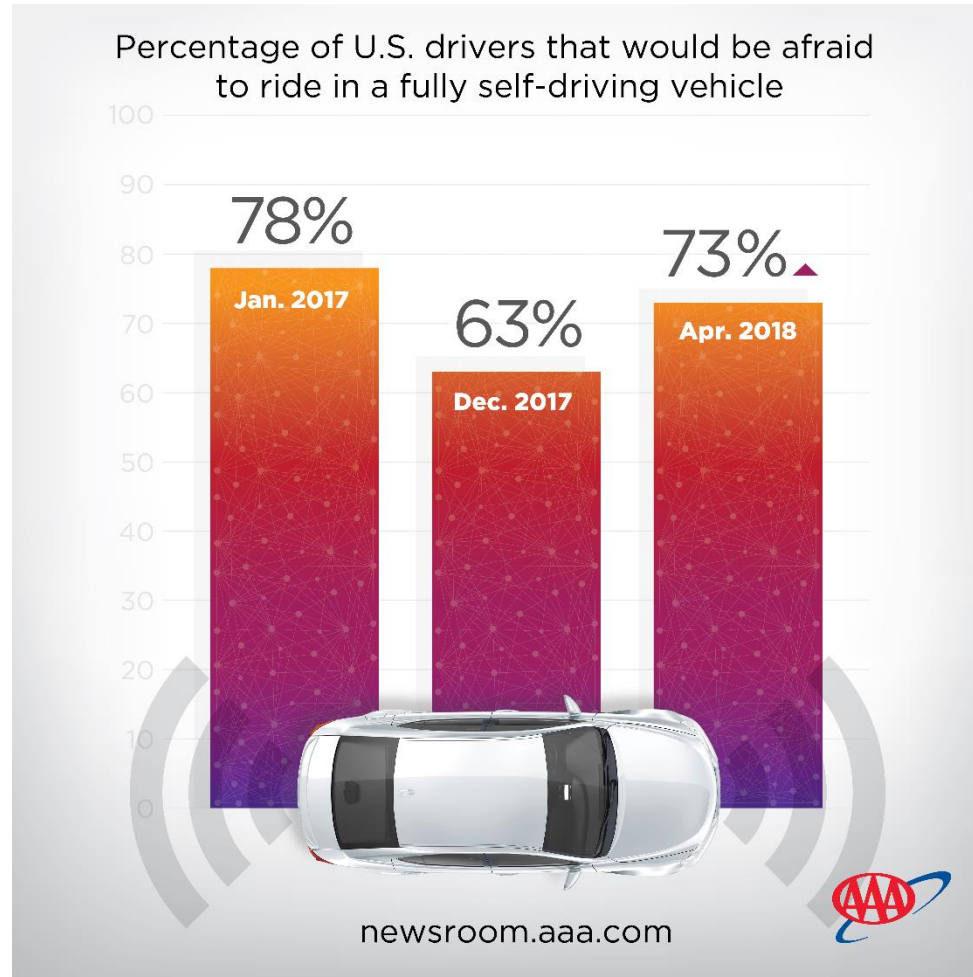
CAV sentiments

HNTB: Eighty percent of Americans expect benefits from autonomous vehicles once they are on the road



CAV sentiments

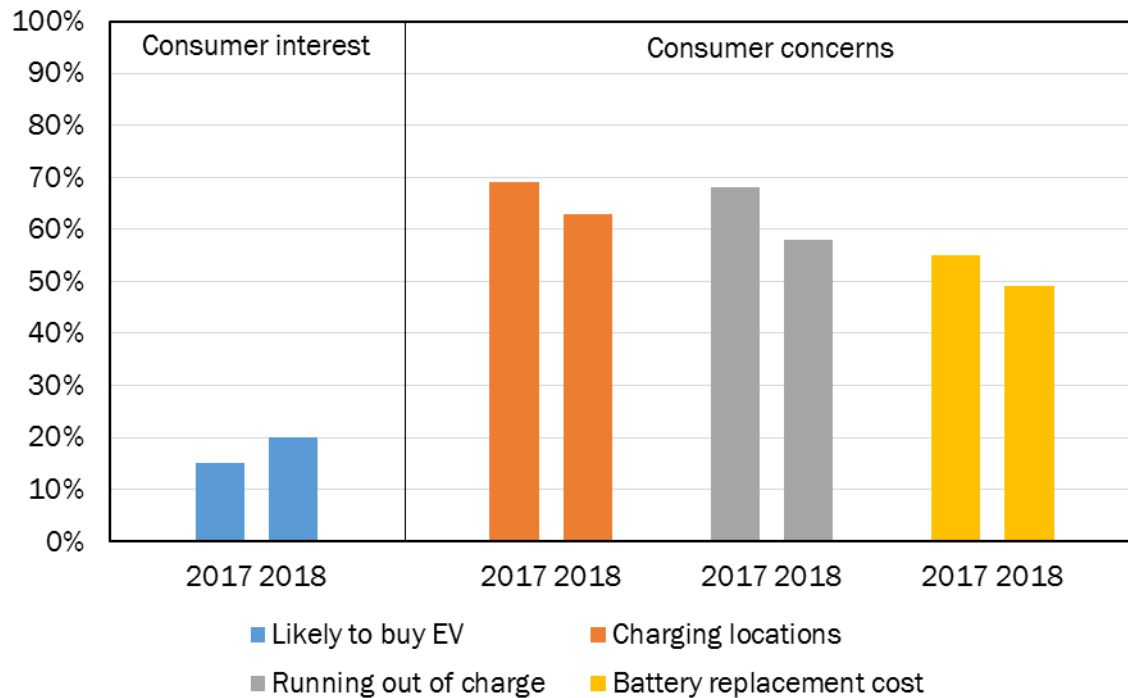
➤ **AAA: After some high-profile incidents, nearly three-fourths of U.S. drivers would be afraid to ride in an AV**



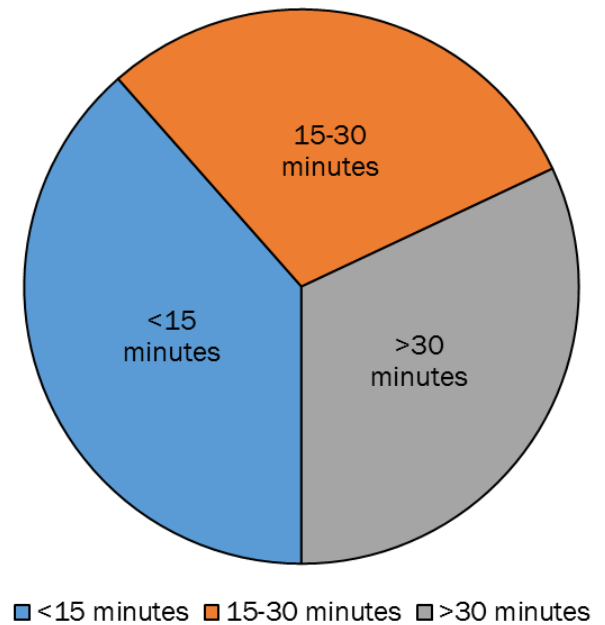
PEV sentiments

AAA: Americans are becoming more interested in and less concerned about electric vehicles

Consumer interest and concerns about EVs



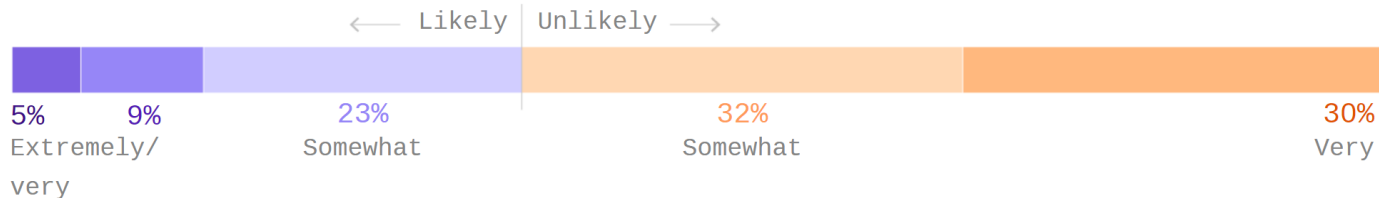
Reasonable time for charging



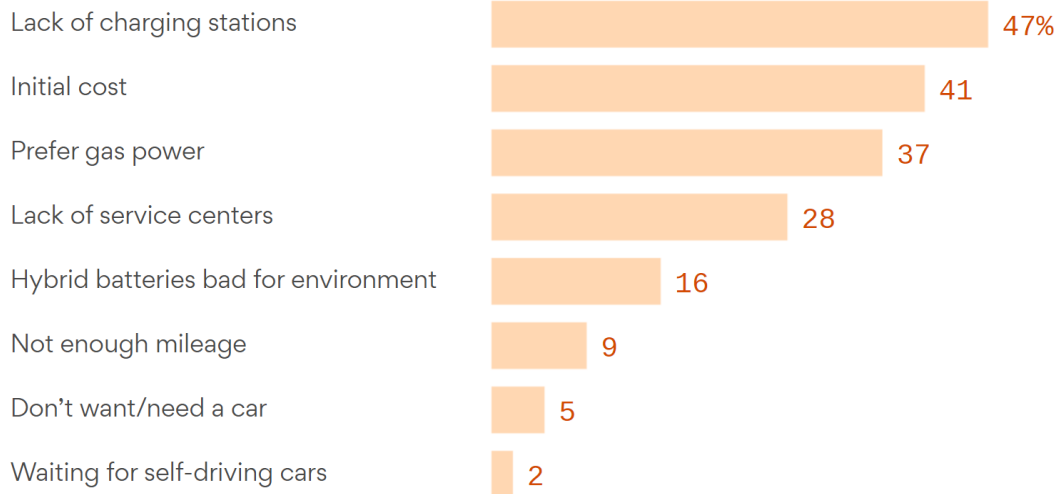
PEV sentiments

Axios: Charging infrastructure and cost are preventing Americans from considering buying EVs

How likely are you to buy or lease an electric car?



If unlikely, why?



Data: Survey Monkey poll conducted May 22-24, 2018. [Poll methodology](#); Chart: Chris Canipe/Axios

Source: <https://www.axios.com/axios-surveymonkey-poll-electric-cars-have-huge-growth-potential-3e087abd-764c-471a-904a-ac47b4dc1fd5.html>

topics

energy markets

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technologies studies

environmental studies

behavior & opinion surveys

6 policy & business studies **qar**
outline

6 policy & business studies

vehicle assembly

- > ANL: A higher fraction of BEV than ICE are domestically produced
- > ICCT: For BEV, the U.S. imports more batteries than it exports

fuel economy standards

- > EIA: Holding GHG/CAFE standards steady after 2020 will result in an extra quad of energy being used
- > NHTSA: MY17 vehicles are not projected to meet CAFE standards

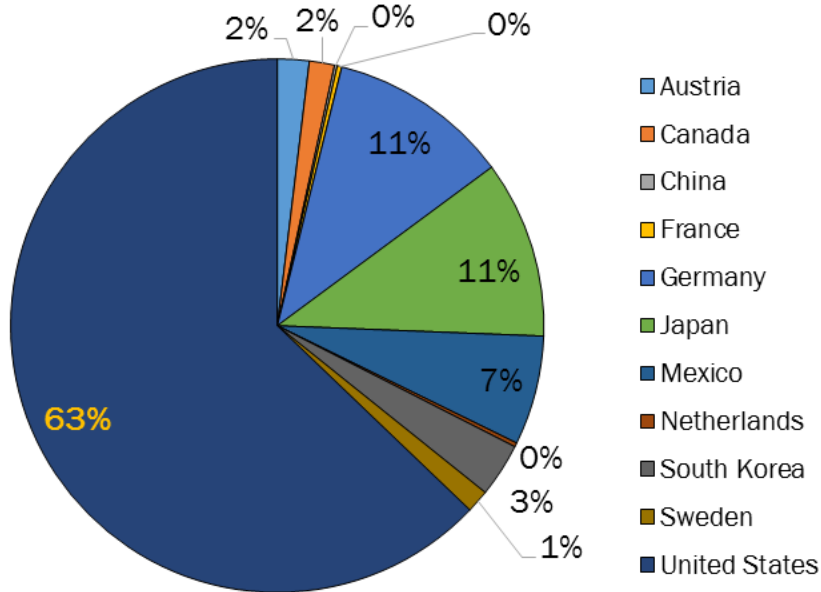
freight

- > NYC: Nearly half of New Yorkers receive a delivery a few times a week
- > ICCT: Autonomous vehicles are projected to be common in freight in about a decade

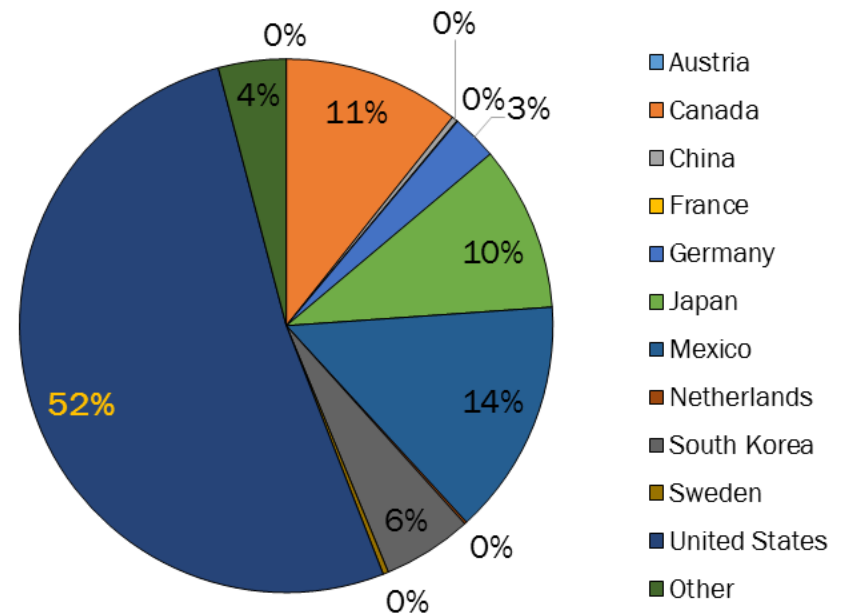
vehicle assembly

ANL via EnergyFuse: A higher fraction of PEVs than non-PEVs sold in the U.S. were domestically assembled in 2017

PEV sales by country of origin, 2017



Non-PEV sales by country of origin, 2017



vehicle assembly

ICCT: Of major EV producers, only Japan is a large net vehicle exporter

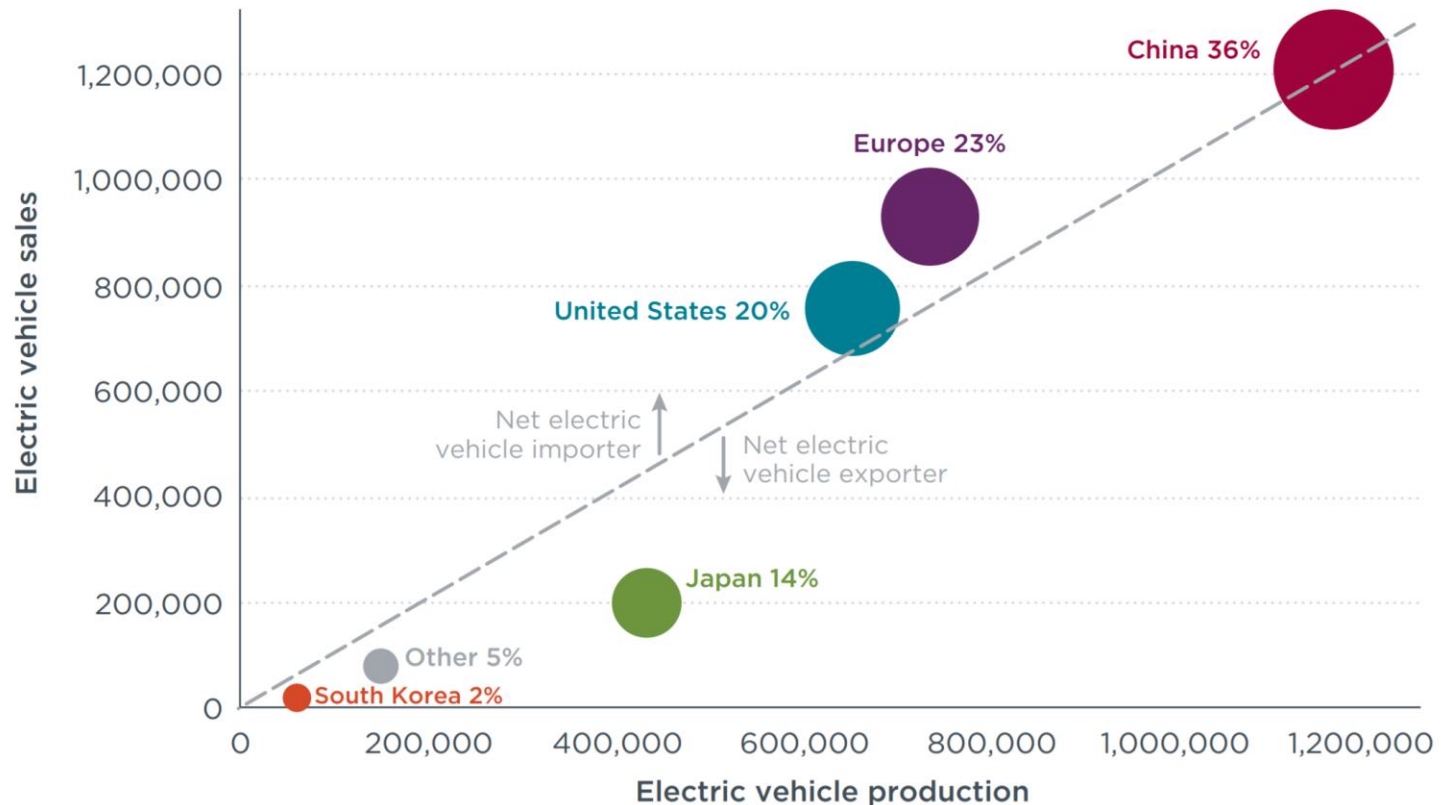


Figure 1. Cumulative electric vehicles sales and production from 2010 through 2017, in major regions, with circle size proportional to the percentage of global electric vehicles produced.

vehicle assembly

ICCT: The majority of batteries used in Europe and in U.S. for EV production are imported

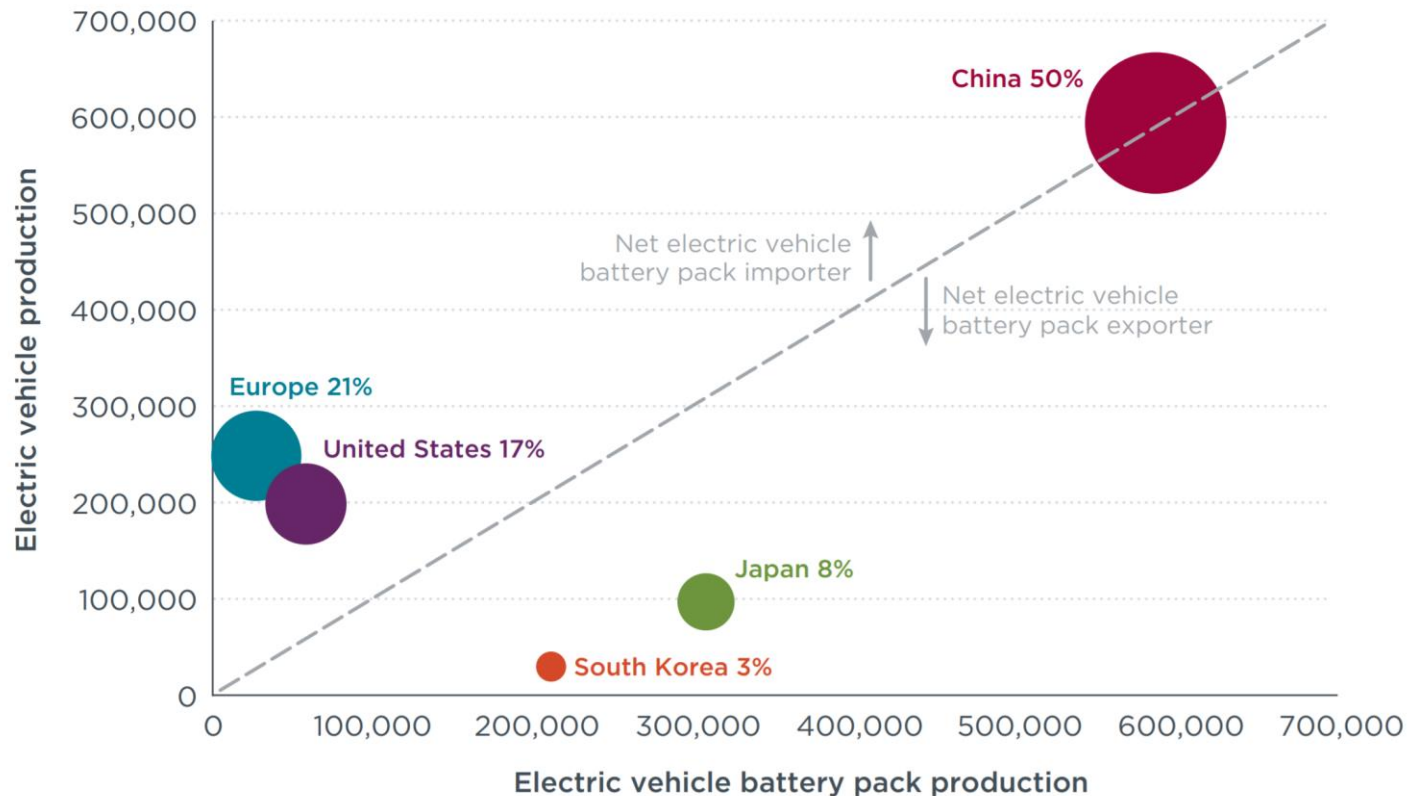


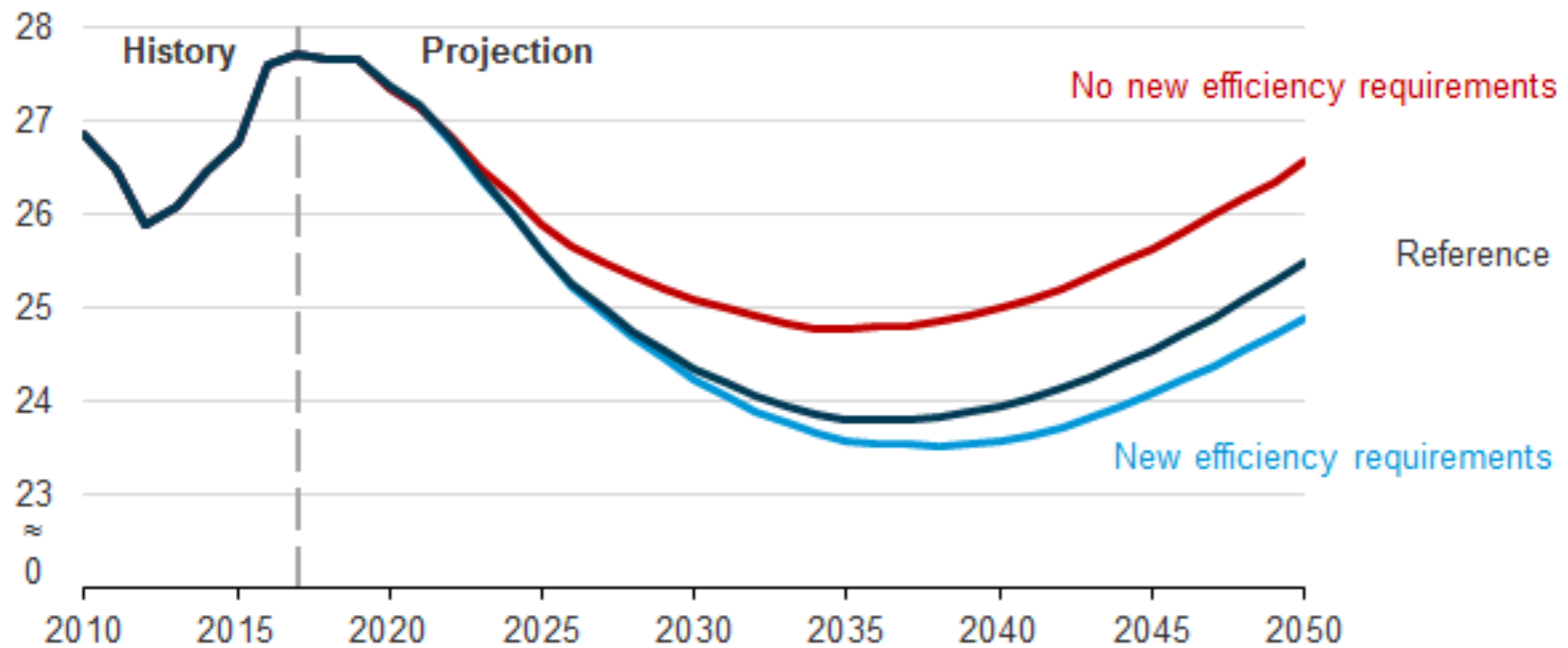
Figure 6. Electric vehicle production and battery production for five major electric vehicle manufacturing regions in 2017, with circle sizes proportional to the percentage of global electric vehicle production.

fuel economy standards

EIA: CAFE/GHG standards at MY21 levels result in 1 additional quad of transportation energy use per year

Figure 10. Transportation energy consumption in three cases, 2010–2050

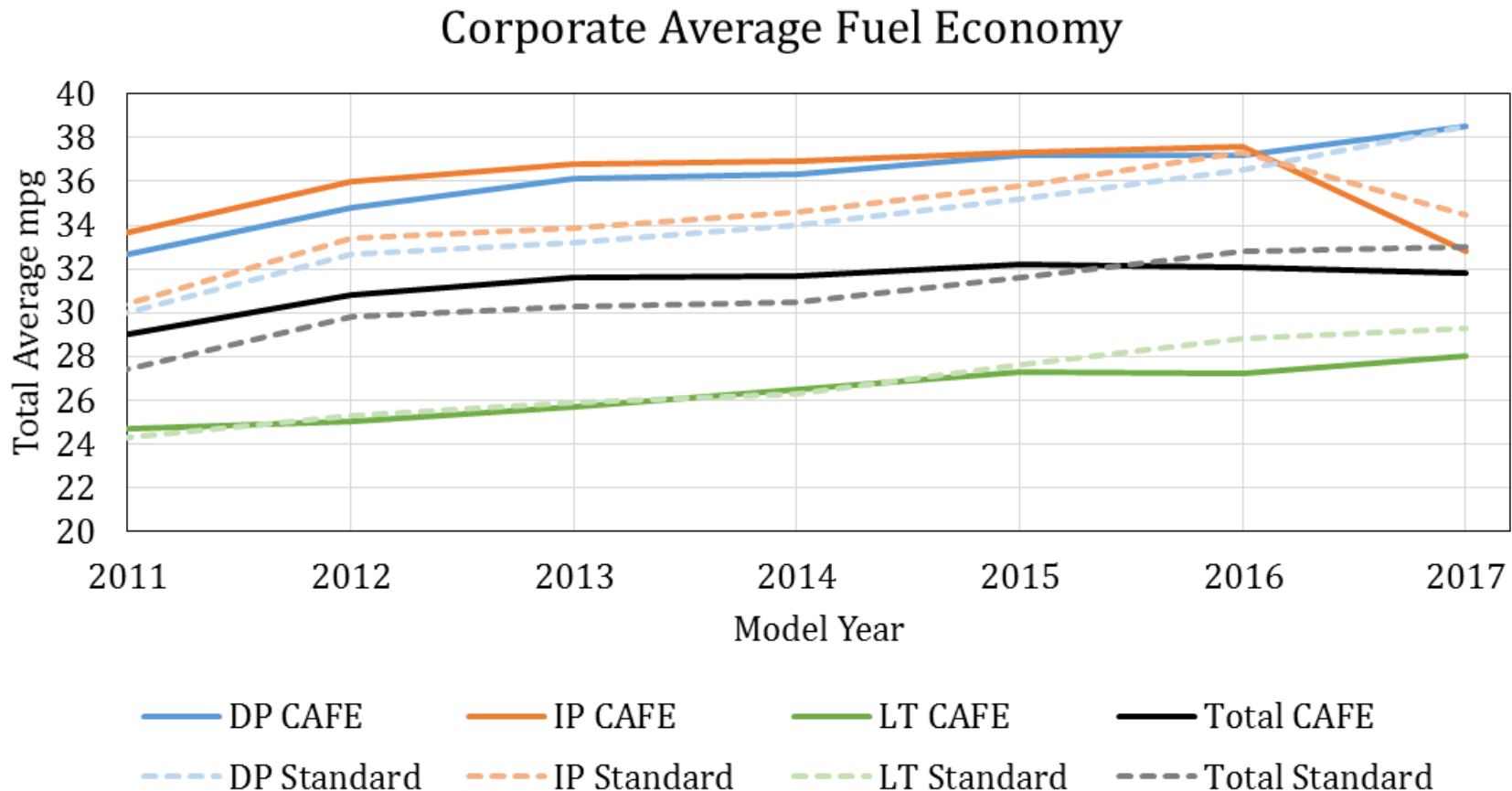
transportation delivered energy consumption
quadrillion Btu



Source: U.S. Energy Information Administration, *Annual Energy Outlook 2018*

fuel economy standards

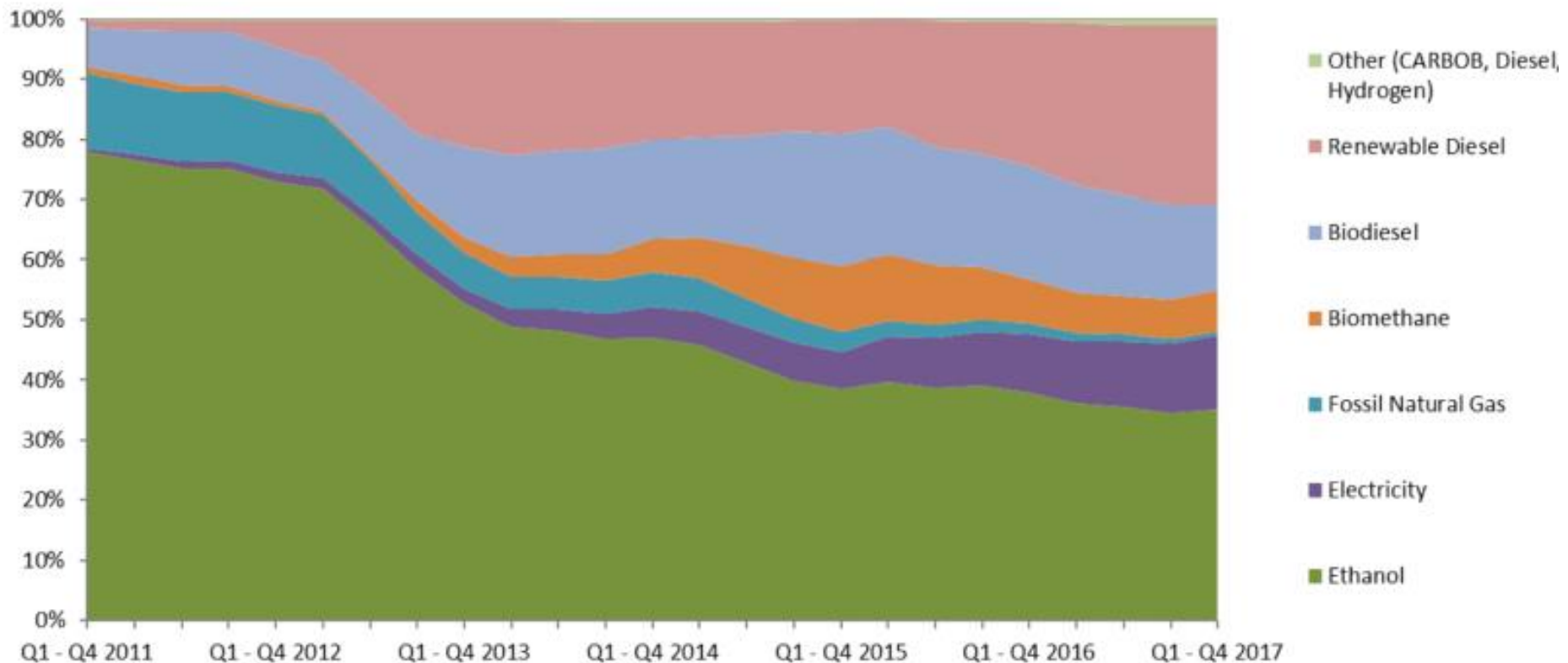
NHTSA: MY17 vehicles (particularly light trucks and import cars) are not projected to meet CAFE standards



low-carbon fuel standards

CARB: Renewable diesel and electricity are generating an increasing amount of LCFS credits in California

Fig 2. Credit Percentage by Fuel
Q1 2011 - Q4 2017



Sources: <http://www.greencarcongress.com/2018/05/20180510-lcfs.html> and https://www.arb.ca.gov/fuels/lcfs/dashboard/quarterlysummary/20180425_q4datasummary.pdf

fuel sales

NACS: Convenience stores sell about 80% of the fuel purchased in the United States

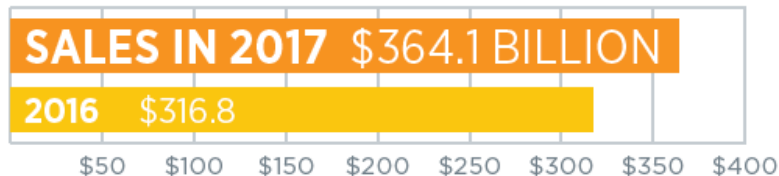
U.S. Convenience Stores Snapshot

FUEL

Convenience stores sell **about 80% of the fuel** purchased in the United States



FUEL SALES

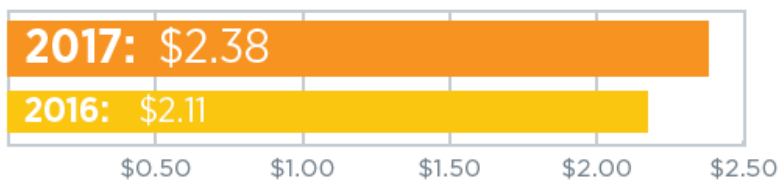


FUEL MARGINS

cents per gallon (before expenses)



AVERAGE GAS PRICES



FUEL TREND

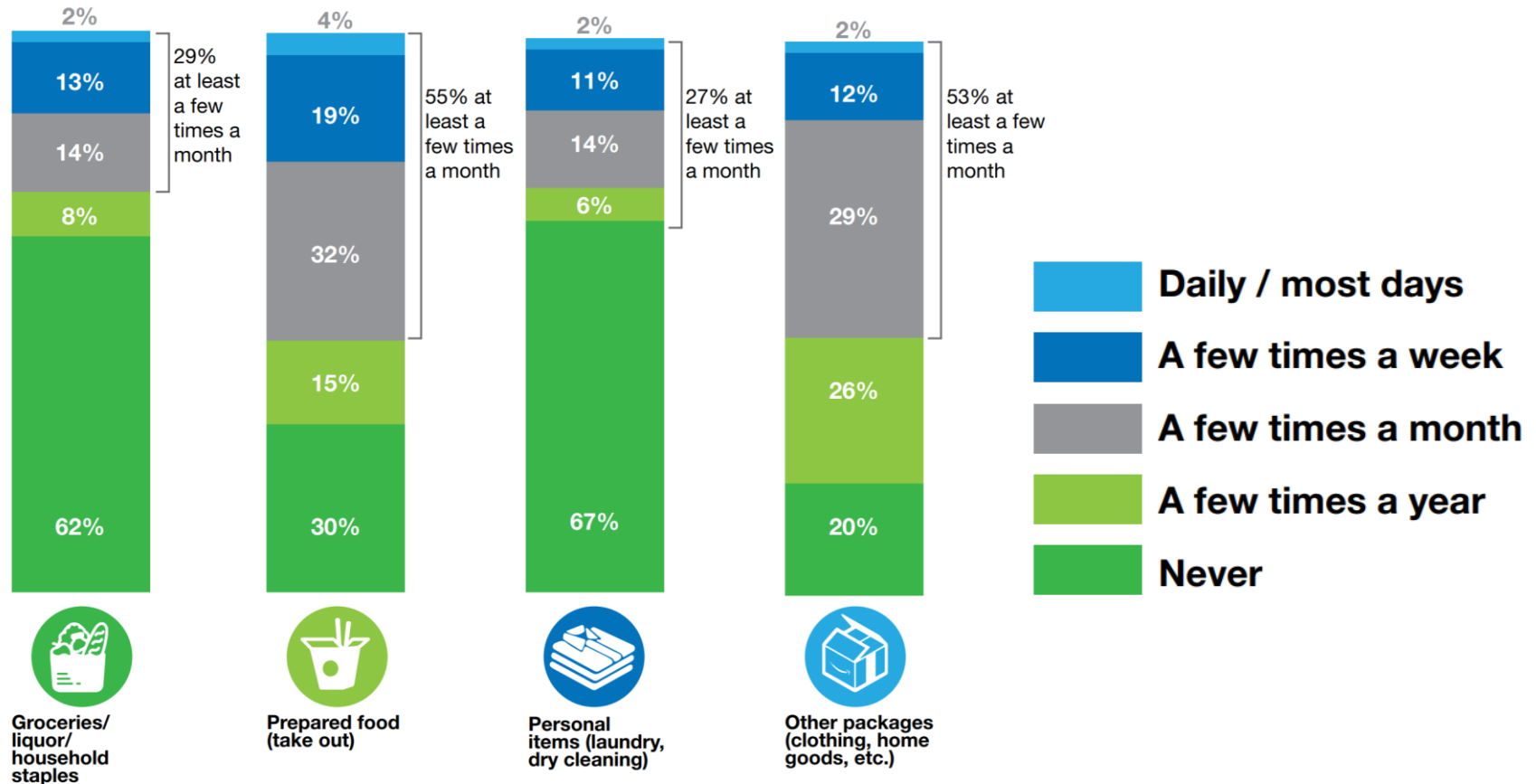
Convenience stores reported a **14.9% increase in fuel sales** in 2017.

freight delivery

NYC: 41% of New Yorkers receive a delivery at their home at least a few times per week

Delivery Behavior:

How often do you receive deliveries at home?



CAVs

ICCT: Full automation of heavy-duty freight trucks is expected by around 2030

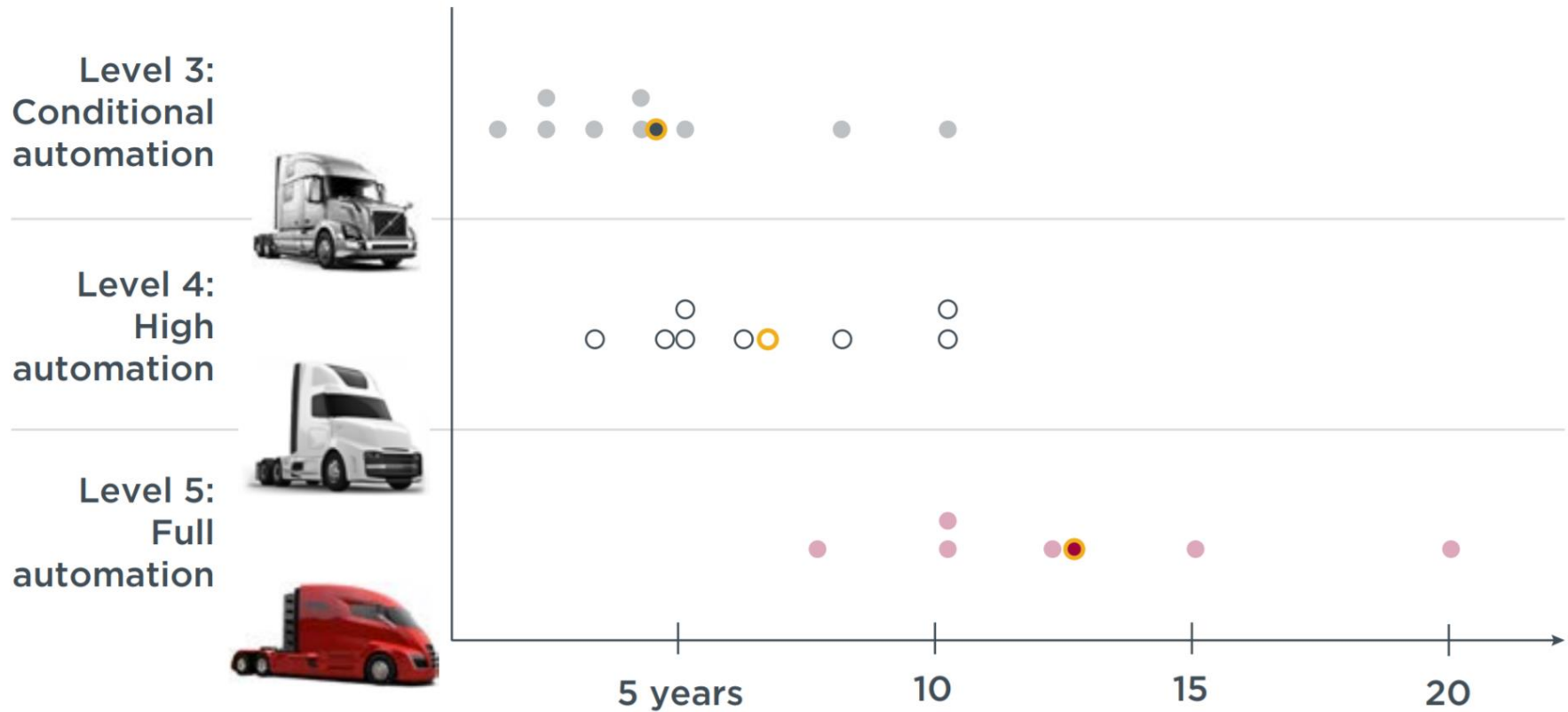
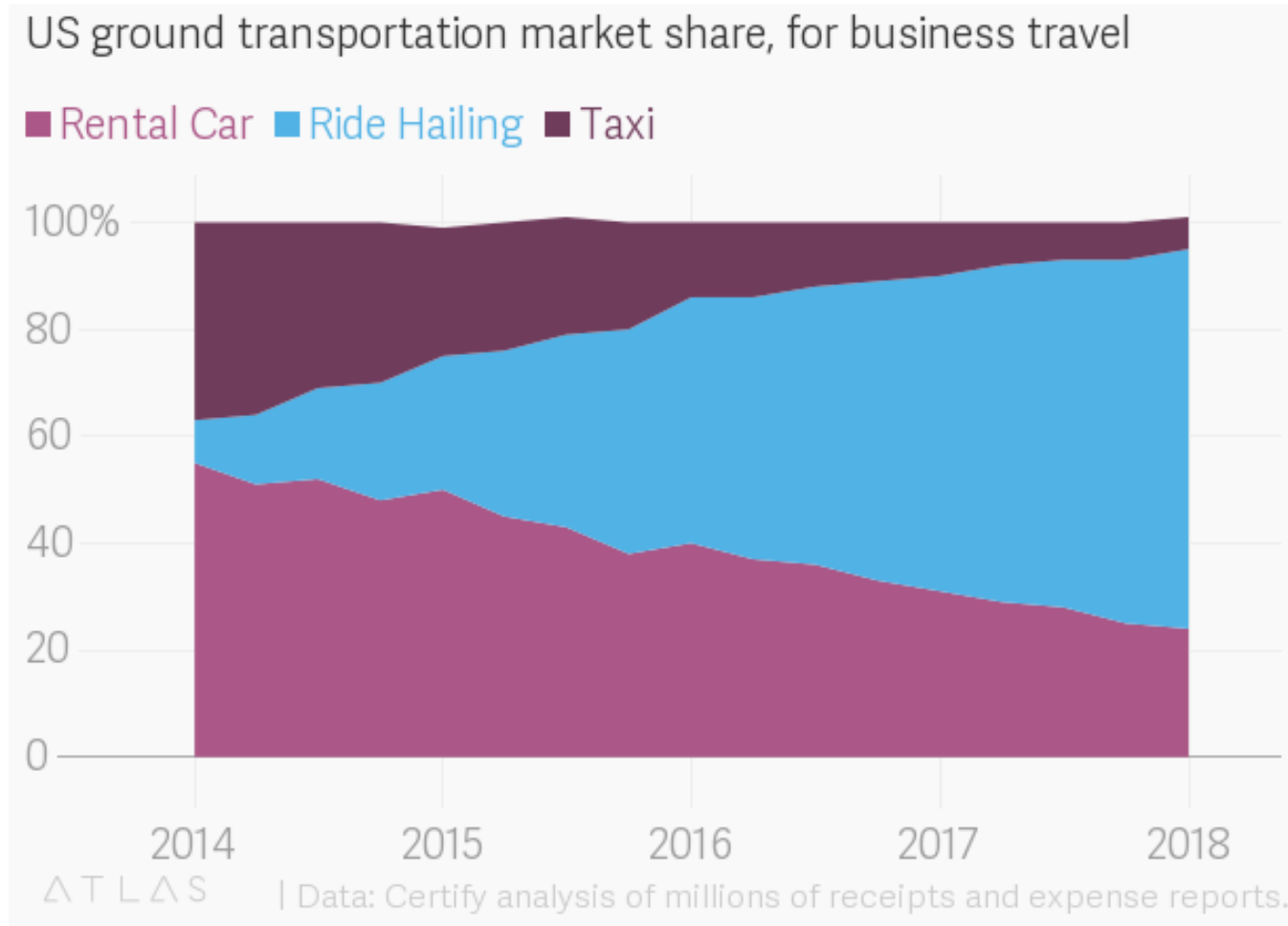


Figure 3. Survey responses: Timeline expectations for the technical readiness of Levels 3, 4, and 5 freight trucks, based on fall 2017 industry survey.

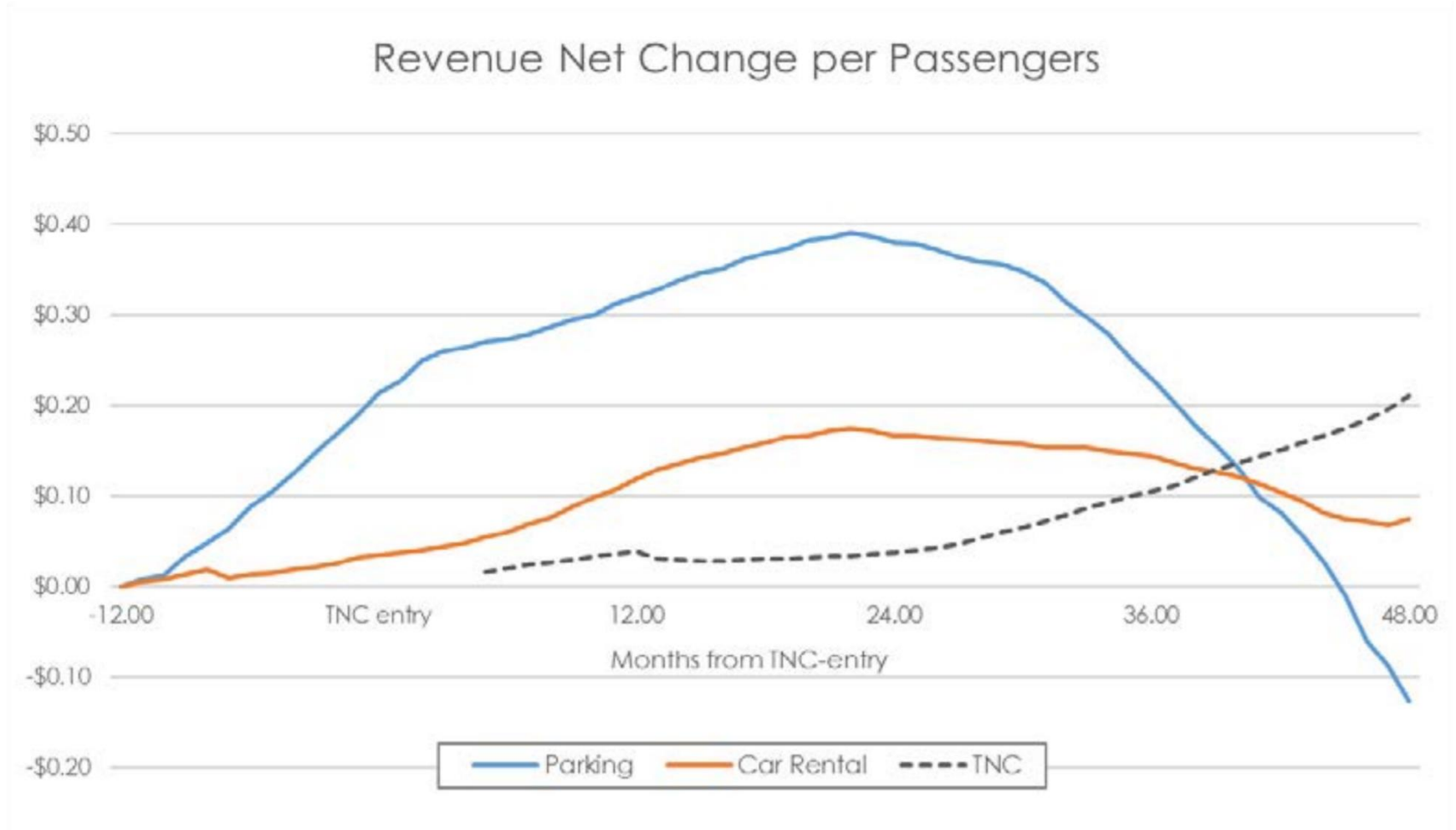
TNCs and travel

➤ **Atlas via QZ: Ride hailing now makes up the majority of ground transportation for business travel**



TNCs and travel

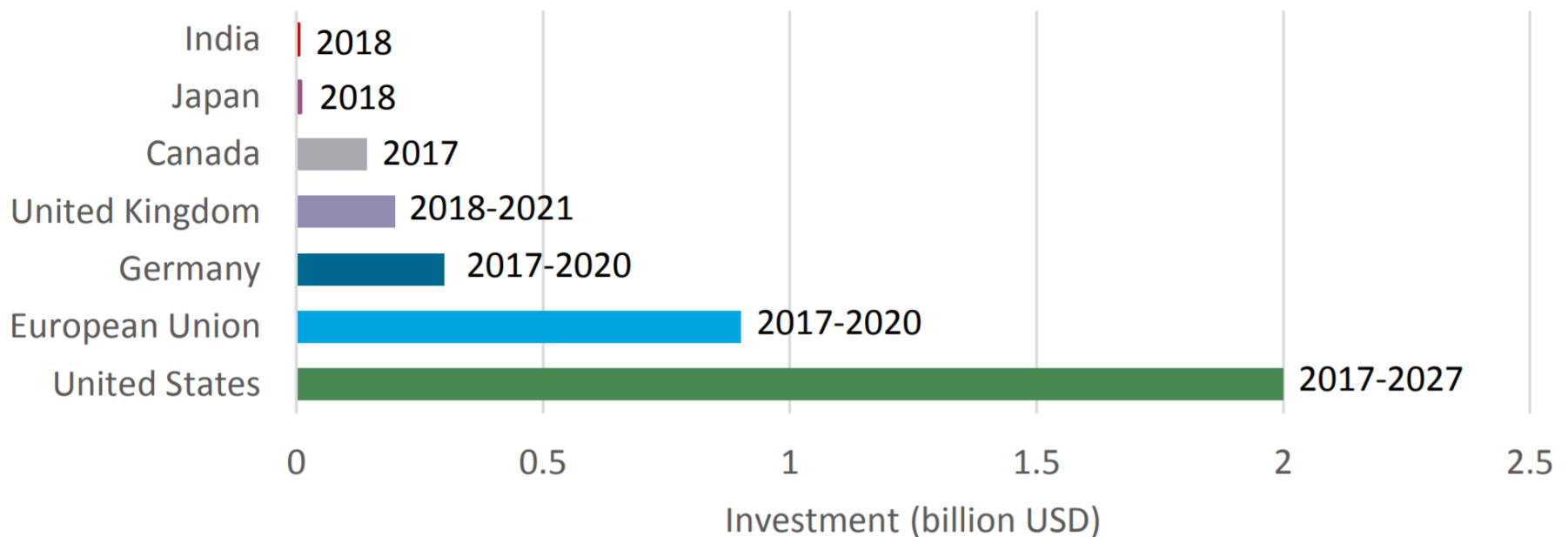
NREL: Fees on TNC usage are partially offsetting loss in airport revenue from parking and rental cars



EV charging infrastructure

IEA: Billions of dollars are committed to PEV charging infrastructure in the next decade

Figure 3.5 • Recent investment announcements for EV infrastructure development in selected countries



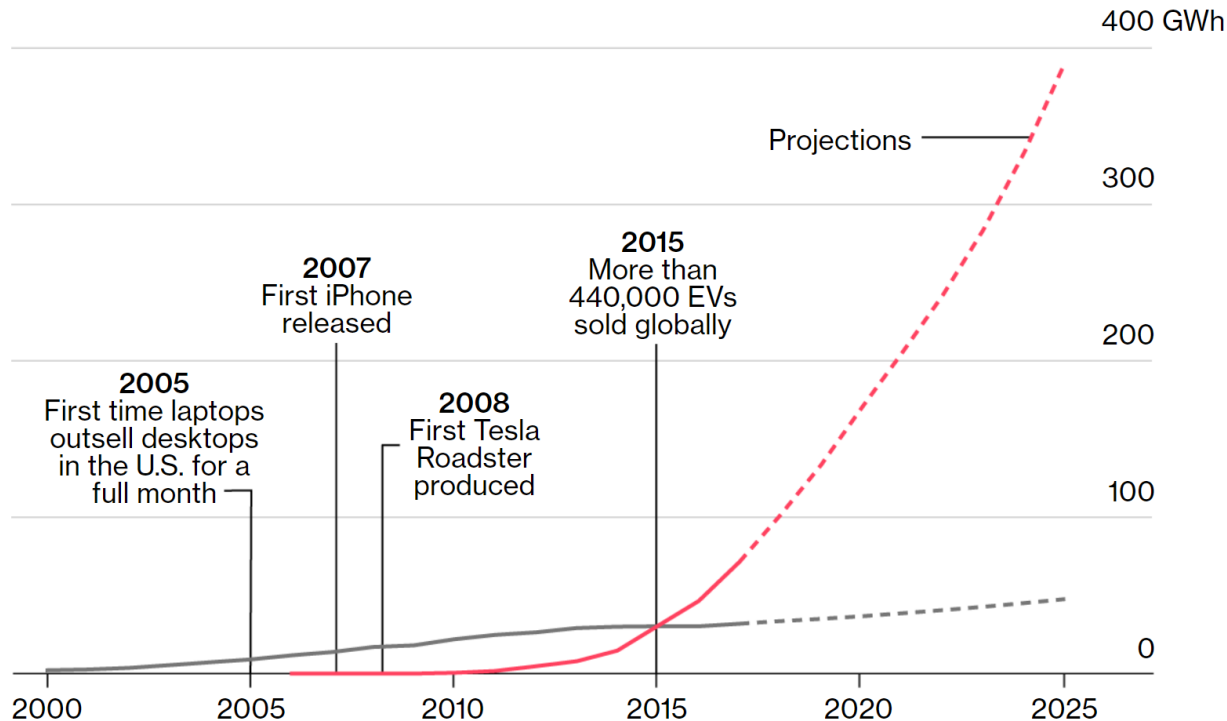
critical materials

Avicenne via Bloomberg: There is now more global demand for Li-ion batteries in EVs than electronics

EVs Dominate Demand for Lithium-Ion Batteries

Estimated global demand by product, in gigawatt-hours

— Electronics — EVs



Sources: Avicenne; BNEF; Current Analysis; Bloomberg reporting

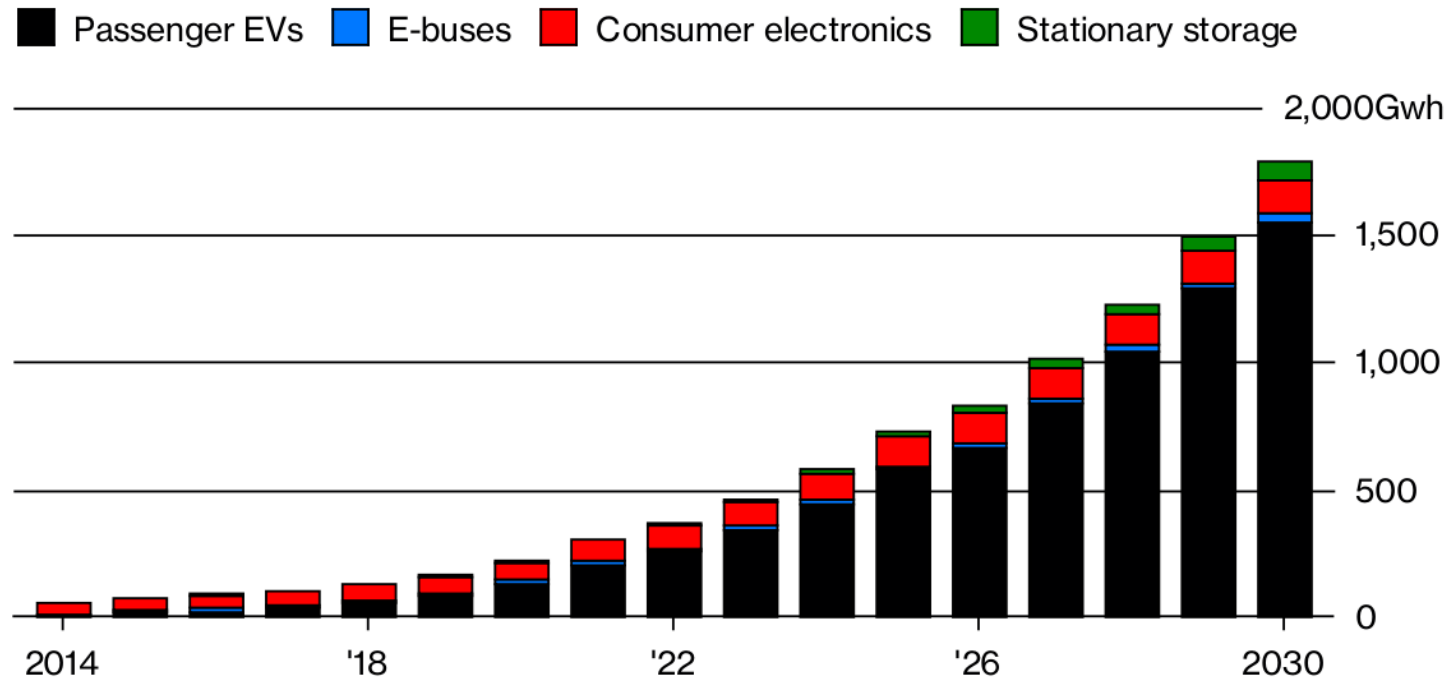
Note: EVs refers to cars and buses

critical materials

BNEF: There will soon be more global demand for lithium-ion batteries in EVs than electronics

All Ahead for Electric Vehicles

Transport demand for lithium-ion batteries will soon overtake consumer gadgets

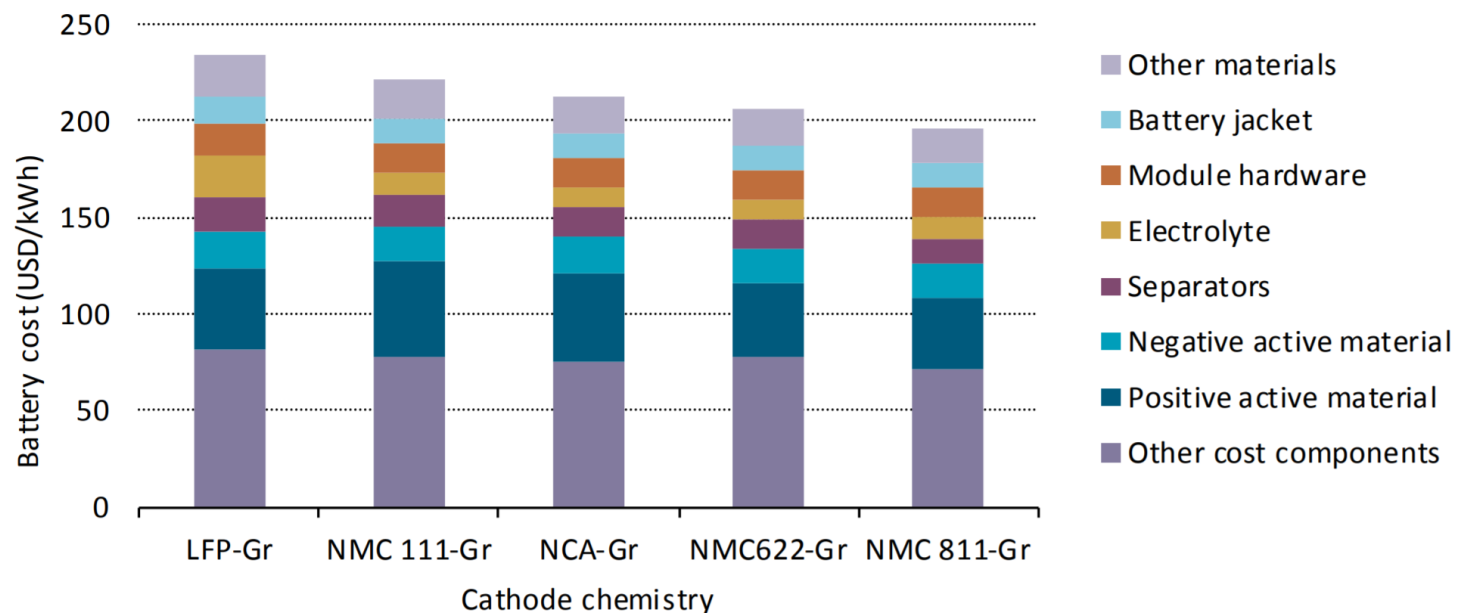


Data: Bloomberg New Energy Finance; graphic by Bloomberg Businessweek

critical materials

IEA: Battery chemistry affects battery prices – reduction of cobalt will reduce price

Figure 5.2 • Effect of change in battery chemistry on costs



Notes: Gr = graphite. Battery costs are evaluated for a 35 kWh electric vehicle battery produced at 100 000 packs per year using BatPaC V3.1. The software default settings were used for cost shares and cathode cost (USD 20/kg). Cathode costs imply metal prices around: USD 9/kg for nickel, USD 2/kg for manganese, USD 30/kg for cobalt, and USD 8/kg for Li_2CO_3 . NMC 811 technical parameters are based on expert judgement and were developed on the basis of personal communications with S. Ahmed (Argonne National Laboratory).

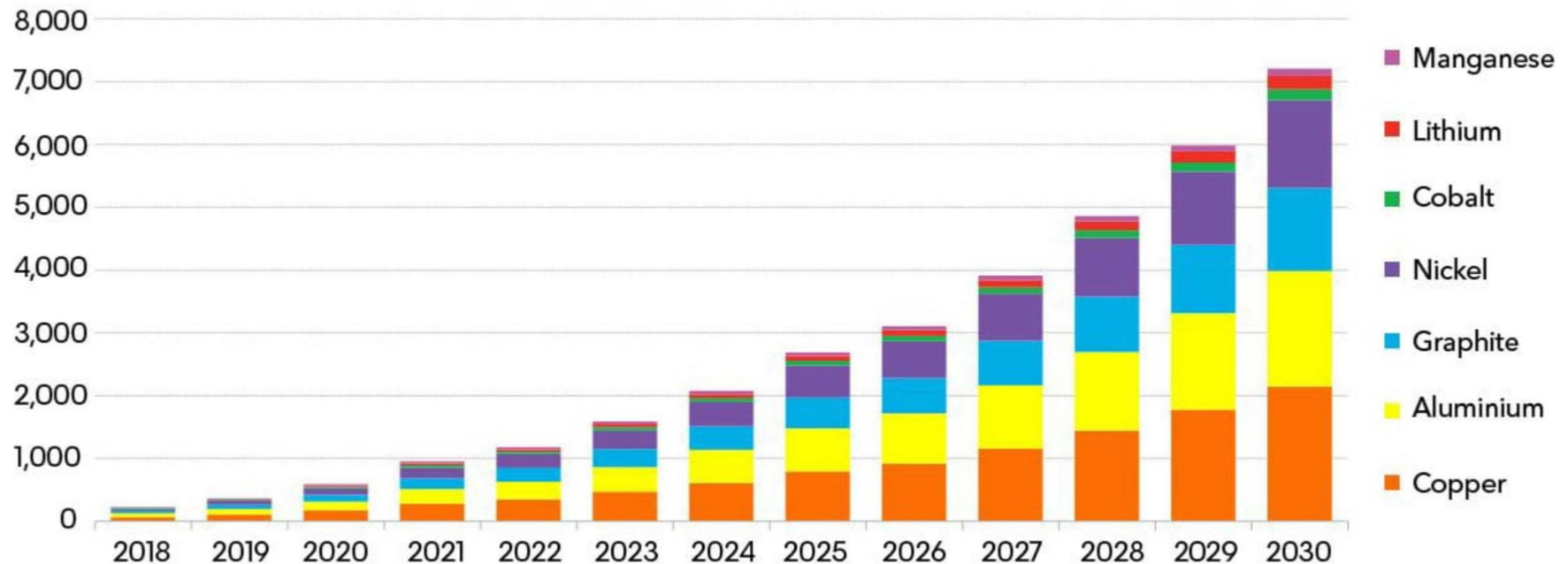
Source: IEA analysis based on ANL (2018).

critical materials

BNEF: Millions of metric tons of critical battery materials will be necessary by 2030

Metals and materials demand from lithium-ion battery packs in passenger EVs

Thousand metric tons



Source: *Electric Vehicle Outlook 2018, Bloomberg New Energy Finance*. Note: Copper includes copper current collectors and pack wiring. Aluminium includes aluminium current collectors, cell and pack materials and aluminium in cathode active materials.

summary observations



energy

U.S. gasoline prices are at their highest point in four years; crude oil and gasoline exports are at record levels

automotive

Average LDV price (inflation-adjusted) has grown about 1% per year since 2012

tech/enviro

High penetration of autonomous vehicles could increase U.S. transportation energy by 10%; EVs emit less CO₂ than HEV through most of country

opinion/policy

People expect AVs will be common within a decade; flat fuel economy standards can increase energy usage by 1 quad; more than half of PEVs are assembled in the U.S.

18.2
2Q 2018

qar
summary